The University of Chicago

AN EXPERIMENTAL INVESTIGATION OF EYE MOVEMENTS IN LEARNING TO SPELL WORDS

A DISSERTATION SUBMITTED TO THE
GRADUATE FACULTY IN CANDIDACY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATION
1931

By
LUTHER CALVIN GILBERT

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ACKNOWLEDGMENTS

The writer is under obligation to Mr. Robert C. Woellner, Mr. Harry O. Gillet and to the teachers of the University of Chicago Laboratory Schools for their coöperation in arranging for the participation of pupils in the investigation. Obligation is also acknowledged for the kindness of a number of University students who acted as subjects. To Doris Wilcox Gilbert grateful appreciation is expressed for her assistance in the laboratory.

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AN EXPERIMENTAL INVESTIGATION OF EYE MOVEMENTS IN LEARNING TO SPELL WORDS

Introduction

The visual presentation of words in the teaching of spelling has long been a matter of interest to educators. Even so far back as the time of Pestalozzi men were arguing the respective merits of the " seeing method " and the " hearing method ". One of the earliest investigators to put the matter to the test was Lay.[1] In 1895 he studied a number of German school children and found that reading words from the board was from two to three times as effective for learning as listening to the dictation of the words. Abbott,[2] Carey,[3] Kratz,[4] and Whitehead[5] have also studied the relative worth of various methods of learning to spell.

Marique[6] found that explaining a word, pronouncing each syllable, writing it on the blackboard and having the pupils spell it and trace it, brought twice as good results as explaining the word, pronouncing the letters separately and having the pupils repeat the spelling orally, The " best methods " of Winch,[7]

[1] Lay, W. A. Führer durch den Rechtschreib Unterricht. Wiesbaden, 1899.

[2] Abbott, Edwina. On the Analysis of Memory Consciousness in Orthography. *Psychological Review Monograph Supplement,* 1909, 11, 127–158.

[3] Carey, N. Factors in the Mental Processes of School Children. *British Journal of Psychology,* 1914–1915, 7, 453–490.

[4] Kratz, H. E. A Study in Spelling, Studies and Observations in the Schoolroom. Boston, Educational, 1907, pp. 127–140.

[5] Whitehead, L. G. A Study in Visual and Aural Memory Processes. *Psychological Review,* 1896, 3, 258–269.

[6] Marique, P. J. An Experimental Investigation in French Orthography. Unpublished thesis, New York University, 1911. (This account from Tidyman, Teaching of Spelling, New York, *World,* 1919, pp. 68.)

[7] Winch, W. H. Experimental Researches in Learning to Spell, *Journal of Educational Psychology,* 1913, 4, 525–537, 579–592. Further Experimental Research in Learning to Spell, *Journal of Educational Psychology,* 1914, 5, 449–460. Additional Researches in Learning to Spell, *Journal of Educational Psychology,* 1916, 7, 93–110.

Fulton,[1] Pearson,[2] Schiller-Hagenmuller-and-Fuchs,[3] and Gates,[4] likewise include the opportunity to *see* the word. Experimental investigations are in accord in indicating that for purposes of group instruction visual presentation is an essential part of superior methods.

This fact being established and generally accepted as a valid principle in teaching, the question arises, " What takes place upon the visual presentation of the words for study? " The significance of the answer for educational science is apparent. Equally apparent is the complexity of the phenomenon.

The purpose of the present investigation is to study one phase of the reaction, namely, the eye movements. What characterizes the eye movements of individuals in learning to spell new words? Eye movements are symptoms of the processes which go on in the central nervous system and as such furnish the experimenter with the means of making an objective study of what goes on in the experience of a learner when he is trying to master a word.

Purpose of the Study

Part One. More specifically the purpose of the study is to compare good and poor spellers from all the grades, from the third year of the elementary school to the senior year of the high school, and to ascertain something of the nature of growth with respect to the following points:

(1) The number of fixations during the study period.

(2) The order of fixations.

(3) The total time spent in study and the average duration of fixations.

(4) The regularity of fixation lengths.

(5) The unit of study.

(6) The number and types of regressions.

[1] Fulton, M. J. An Experiment in Teaching Spelling. *Pedagogical Seminary,* 1914, 21, 287–289.

[2] Pearson, H. C. Experimental Studies in Teaching Spelling. *Teachers College Record,* 1912, 13, No. 1, Part 2.

[3] Schiller, Hagenmuller and Fuchs. Studien und Versuche über die Erlernung Orthographie, Berlin, 1898.

[4] Gates, A. I. Psychology of Reading and Spelling. Teachers College Contributions to Education No. 129, 1922.

Part Two. Further, it is the purpose to determine the methods of attack commonly used by:

(1) Efficient learners in studying words that are easy.

(2) Inefficient learners in studying words that are not difficult.

Previous Studies

So far as the writer can discover, there is only one article appearing in the literature which deals with eye movements in the learning of spelling. In 1929 Miss E. M. Abernethy [1] photographed the eye movements of four good and four poor spellers of the sixth grade and of four university graduate students. Her purpose was to compare the three groups with respect to the method of learning to spell, as indicated by the eye movement records, with efficiency in learning. The article does not always make clear the techniques employed in calculation.

In brief, the results pointed to the following facts: University students tend to employ a broader recognition unit in study, take less time for each fixation, and make fewer regressive movements than do elementary school pupils. A negative relationship exists between time of learning and efficiency. In the sixth grade, good spellers tend to concentrate on difficult parts of the word. The average duration of pauses of poor spellers of the sixth grade is somewhat less than that of good spellers. University students tend to study mainly by repeated surveys of the word. Attention is more largely directed to the centre of the word than to the initial and ultimate syllables. Adults in their surveys tend to study by syllables, going over the difficult parts letter by letter. Adults use relatively few regressions and these are largely confined to difficult sections. Individuals within groups vary as to their methods of study.

Apparatus Employed in the Investigation Here Reported

The eye movements were recorded in the present investigation by means of a modified form of the photographic apparatus used

[1] Abernethy, E. M. Photographic Records of Eye Movements in Studying Spelling. *Journal of Educational Psychology,* 1929, 20, 695–701.

by C. T. Gray[1] in his study of types of reading ability. His monograph contains a detailed description of the apparatus as it was in 1917. Subsequent modifications have been made by other University of Chicago investigators and are described by Buswell,[2] Gilliland,[3] Terry,[4] and others.

In brief, the method consists of photographing a beam of light, generated by a high powered Tungsarc bulb and reflected to the cornea of the left eye by a silvered glass mirror. A tuning fork vibrating at the rate of twenty-five times per second interrupts the beam of light, with the result that the photographic record emerges as a series of dots which serves as a time record.

The subject is seated before the camera and fastened securely by means of a metal band which encircles the head, and by two cheek rests. Slight movements are still possible, but may be detected and allowed for by means of a head line on the film, obtained by photographing the reflection of the light from a nickel plated bead attached to a pair of spectacle rims worn by the subject.

The rays of light from the bead and from the left eye are reflected through the lenses and the body of the camera and are focussed on the moving film.

Before studying a word, the subject fixates a dot just above the first letter of the word, then a dot just above the last letter of the word. The photographs of these fixations constitute guides for plotting the record. The developed film is projected on a screen at such a distance from the projector that the projections of the guides are exactly as far apart as the length of the printed word which was studied. With the bead line indicating the posi-

[1] Gray, C. T. Types of Reading Ability as Exhibited Through Tests. Supplementary Educational Monograph No. 5, University of Chicago Press, 1917.

[2] Buswell, G. T. An Experimental Study of the Eye Voice Span in Reading, Supplementary Educational Monograph No. 17, University of Chicago Press, December, 1920. Fundamental Reading Habits, Supplementary Educational Monograph No. 21, University of Chicago Press, June, 1922.

[3] Gilliland, A. R. Photographic Methods of Studying Reading. *Visual Education,* Vol. 2, No. 2, 1921.

[4] Terry, P. W. How Numerals are Read. Supplementary Educational Monograph No. 18, University of Chicago Press, June, 1922.

tion of the head and so serving as a line of reference, the record is plotted on blank paper fastened to the screen. Vertical pencil strokes indicate the position of the fixations: the strokes are labelled above with numbers indicating their serial order and below with numbers indicating their duration in twenty-fifths of a second.

The roughly plotted records are then transferred to printed copies of the word, identical with the copy studied before the camera. Finally, to facilitate analysis, the records are translated into graphic form, with horizontal lines indicating the direction and length of the eye movements between the successive fixations and with connecting vertical lines indicating by their length the duration of fixations in twenty-fifths of a second.

Subjects of the Investigation

Sixty-seven subjects were used in the investigation. Three were adults of graduate or undergraduate university standing; all of them were excellent spellers. Thirty-two subjects were high school students. Eight were subfreshmen, four of them good spellers and four poor spellers. For each of the other high school years there were three good and three poor spellers. Thirty-two subjects were elementary school pupils, four good and four poor spellers each from the third, fourth, fifth and sixth grades.

Nearly all of the selections of subjects were made on the basis of a fifty-word test. One exception was made in the case of a graduate student who was teaching in the English Department of the University of Chicago, and who had the reputation of being an excellent speller. Since his coöperation necessitated a long trip at a time when he was extremely busy, the fifty-word test was omitted.

The third grade pupils were selected by their teacher, who had had the class under her charge for at least seven months prior to the investigation.

For the adults and high school students a single test of fifty words was made up from the most difficult lists of the *Sixteen*

Spelling Scales.[1] For grades four, five and six in the elementary school appropriate tests were compiled from words of fifty per cent difficulty for the grade concerned, from the Buckingham Extension of the Ayres Scale.

Fifty-word tests were given to:

150 college students
60 high school seniors
51 high school juniors
62 high school sophomores
68 high school freshmen
49 high school subfreshmen
53 elementary school sixth grade pupils
64 elementary school fifth grade pupils
57 elementary school fourth grade pupils

The good spellers were selected from the upper quarter of the group at each level, the poor spellers from the lower quarter. Standardized test records from the Laboratory Schools of the University of Chicago, from which the elementary and high school pupils were selected, showed that all the subjects chosen were of at least average intelligence. No pupil had any physical handicap which would affect his spelling ability.

The coöperation of all the subjects was good. The small children were much less difficult to photograph than was anticipated. As a rule, only five or six minutes elapsed between the adjustment of the subject before the camera and his release. Such periods were too short to produce undue fatigue or boredom.

Procedure

Each subject was pre-tested on the five words which he was to study before the camera. The investigator dictated the words one at a time and the pupil wrote them down on paper.

The subjects were then photographed one at a time, with no other person present in the room except the investigator and an assistant. In a preliminary explanation the pupil was asked to learn to spell the words before the camera in his usual manner of study, and was told that he would be tested afterward. The preliminary fixations on the dots above the word were explained, and the

[1] *Sixteen Spelling Scales* (Standardized in Sentences for Secondary Schools). Teachers College Bulletin, Columbia University, No. 19, May, 1921.

student was tried out with two practice words to be sure he understood the signals.

The words to be learned were printed on individual cards which were placed before the subject's eyes just beneath the camera lenses. A curtain card, half as high as the other cards, covered the printed words, but revealed the dots. At the command "Study" the curtain card was removed; the instant the subject indicated that he was through with his study, the curtain card was replaced over the word.

Immediately after the last word had been covered, the subject was released and seated at a table for a final written test on the words. This test was an exact repetition of the pre-test. Both pre-test and post-test papers were filed, together with certain observations by the investigator which appeared worthy of note.

Words Used in the Investigation

Three sets of five words each were selected for the investigation; one set for the high school and college students, one set for the fourth, fifth and six grades of the elementary school, and one set for the third grade. The words for the third grade will be designated hereafter as Set One. They were chosen from a list suggested by the third grade teacher; all of them had occurred in connection with the regular classroom activities; none of them had been formally taught. Set One includes:

biscuit	(7 letters)
accident	(8 letters)
success	(7 letters)
scissors	(8 letters)
quarantine	(10 letters)

None of the third grade pupils who acted as subjects could spell any of these words correctly prior to the study period before the camera. On the other hand, no child missed all the letters in any of the words in his initial attempt, that is, no child wrote such letters as *klom* for *biscuit*. The preliminary efficiency was computed by determining the percentage of letters correctly given, with omissions, additions and substitutions deducted as errors. For example, *bisket* for *biscuit* is .57 efficient. The average

preliminary efficiency of the third grade subjects is shown in Table I.

TABLE I

Average Preliminary Efficiency on the Words of Set One—Third Grade

(Spelling efficiency computed by determining the percentage of letters correctly given, with omissions, additions and substitutions deducted as errors.)

Subjects	Third Grade
Good Spellers	.68
Poor Spellers	.50
Good and Poor	.59

The words for grades four, five and six will be designated hereafter as Set Two. They were selected from a list used by Tireman [1] in a study of the value of marking the hard spots in spelling. Set Two includes:

definitely	(10 letters)
accommodate	(11 letters)
rheumatism	(10 letters)
conscientious	(13 letters)
questionnaire	(13 letters)

On the preliminary test none of the subjects spelled any of these words entirely correctly or altogether incorrectly. The average preliminary efficiency is shown in Table II.

TABLE II

Average Preliminary Spelling Efficiency on the Words of Set Two—Grades Four, Five and Six

(Spelling efficiency computed by determining the percentage of letters correctly given, with omissions, additions and substitutions deducted as errors.)

	Grade			
Subjects	Fourth	Fifth	Sixth	Average for All
Good Spellers	.75	.86	.87	.83
Poor Spellers	.43	.52	.59	.51
Good and Poor	.59	.69	.73	.67

The range in preliminary spelling efficiency for the various groups is broad, being from .43 for the poor spellers of the fourth grade to .87 for the good spellers of the sixth grade. Nevertheless, wide variations could scarcely be avoided. It would be

[1] Tireman, L. S. Marking Hard Spots in Spelling. Ph.D. Thesis, University of Iowa, 1927.

almost, if not quite, impossible to find any set of words equally hard for all the groups without using words which all could spell or words which were entirely beyond any of them. An average preliminary efficiency of .43 appears sufficiently high to warrant the use of the words even with the poor spellers; it indicates that they were not unreasonably difficult; in no case did a subject fail completely in his initial attempt to spell a word.

The words of Set Three for the high school and college students were selected from a list of medical, botanical, chemical and zoological terms and words of a non-technical nature, all culled from such popular scientific books as *The Nature of the World and of Man,* Dorsey's *Why We Behave Like Human Beings,* and De Kruif's *Microbe Hunters.* Set Three includes:

ecchymosis	(10 letters)
acanthaceous	(12 letters)
autochthonous	(13 letters)
pteridophyte	(12 letters)
tachygrapher	(12 letters)

Only one member of the groups using these words could spell any of them correctly. The exception was a good speller who spelled correctly the one word *autochthonous* but who said as she wrote it that she was not sure she was correct. The average preliminary efficiency of the college and high school subjects on these words is shown in Table III.

TABLE III

Average Preliminary Efficiency on the Words of Set Three—High School and College Subjects

(Spelling efficiency computed by determining the percentage of letters correctly given, with omissions, additions and substitutions deducted as errors.)

	Grade						
Subjects	Subfr.	Fresh.	Soph.	Junior	Senior	Coll.	All
Good Spellers	.69	.63	.69	.71	.68	.77	.70
Poor Spellers	.41	.48	.44	.60	.53		.49
Good and Poor	.55	.56	.57	.66	.61		.59

The range for these groups is from .41 for the poor spellers of the subfreshman year to .77 for the good spellers of college level; that is, the range for the groups using Set Three is similar to the range for the groups using Set Two.

A comparison of Tables I, II, and III shows a striking similarity in the efficiency averages for all the groups of poor spellers; that for the poor spellers using Set One being .50, that for those using Set Two being .51 and that for those using Set Three .49. In general, then, it is indicated that Set One, Set Two and Set Three were of approximately equal difficulty for the poor spellers who studied them. Further comparison reveals an average preliminary efficiency of .68 for the good spellers using Set One, of .83 for the good spellers using Set Two, and of .70 for those using Set Three. Set One and Set Three, then, were of about the same general difficulty for all the good spellers using them; Set Two was somewhat easier for the good spellers of the fourth, fifth and sixth grades. The difference did not appear sufficient, however, to warrant a change of words.

PART ONE

Specimen Results

Figures 1, 2 and 3 show the records of the eye movements of three individuals learning to spell a word. The positions of the fixations are indicated by the vertical lines. The vertical lengths of the lines of fixation show the durations of the fixations in twenty-fifths of a second. The horizontal lines indicate the direction and length of movements between the successive fixations.

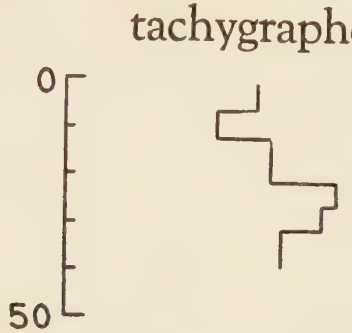


FIGURE 1. STUDY RECORD OF SUBJECT 66, A GOOD ADULT SPELLER. (The vertical axis shows the durations of the fixations in twenty-fifths of a second.)

Figure 1 shows the record of a good speller of the college level learning to spell the word *tachygrapher.* The record in Figure 2 is that of a good speller in the junior year of high school learning to spell the same word *tachygrapher.* Figure 3 is the record of a poor speller in the fourth grade of the elementary school; he worked on the word *rheumatism.*

Some of the characteristics of the record in Figure 1 are the small number of fixations, the brevity of the fixation pauses, their relative regularity of length, and the regressive study movements. The extreme left fixation falls on the first letter *h;* the extreme right fixation falls on the second letter *h;* it was unnecessary to fixate either the beginning or the end of the word. The student

gave the pre-spelling *tyquigrapher*. During the learning period she moved in an orderly manner toward the beginning of the word, then forward, and then back again, making in all six fixations requiring a total of 40 twenty-fifths of a second. Her spelling on the final test was correct. In a general way this procedure represents mature behavior in learning to spell.

The record in Figure 2 is that of a good speller in the junior year of high school. He pre-spelled the word *tekigrapher*. In

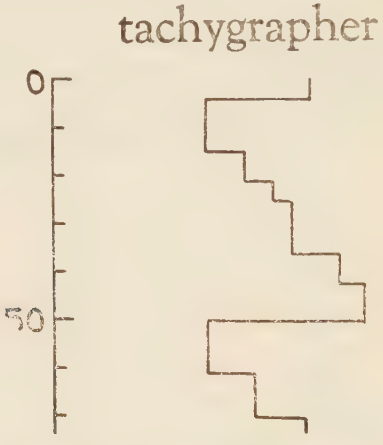


FIGURE 2. STUDY RECORD OF SUBJECT 53, A GOOD SPELLER OF THE JUNIOR LEVEL OF THE HIGH SCHOOL. (The vertical axis shows the durations of the fixations in twenty-fifths of a second.)

the main his study consisted of two forward moving series of relatively regular fixations. In 74 twenty-fifths of a second spent on ten pauses he learned to spell the word correctly. He made no fixations on the first three letters of the word. The fixations occur in fairly regular order, but are more numerous than those of the college student. This study procedure is somewhat less mature than that shown in Figure 1, but more mature than that shown in Figure 3.

Figure 3 presents the record of a poor fourth grade speller who pre-spelled his word (rheumatism) *romatom*. He made 85 fixations totaling 1063 twenty-fifths of a second. On the final test he spelled the word *roomason*. His average fixation time is

somewhat longer than that of the junior high school subject and his pauses are extremely irregular in length, varying from 2 to 41 twenty-fifths of a second. He employs five series of forward movements across the word. The series are irregular with fre-

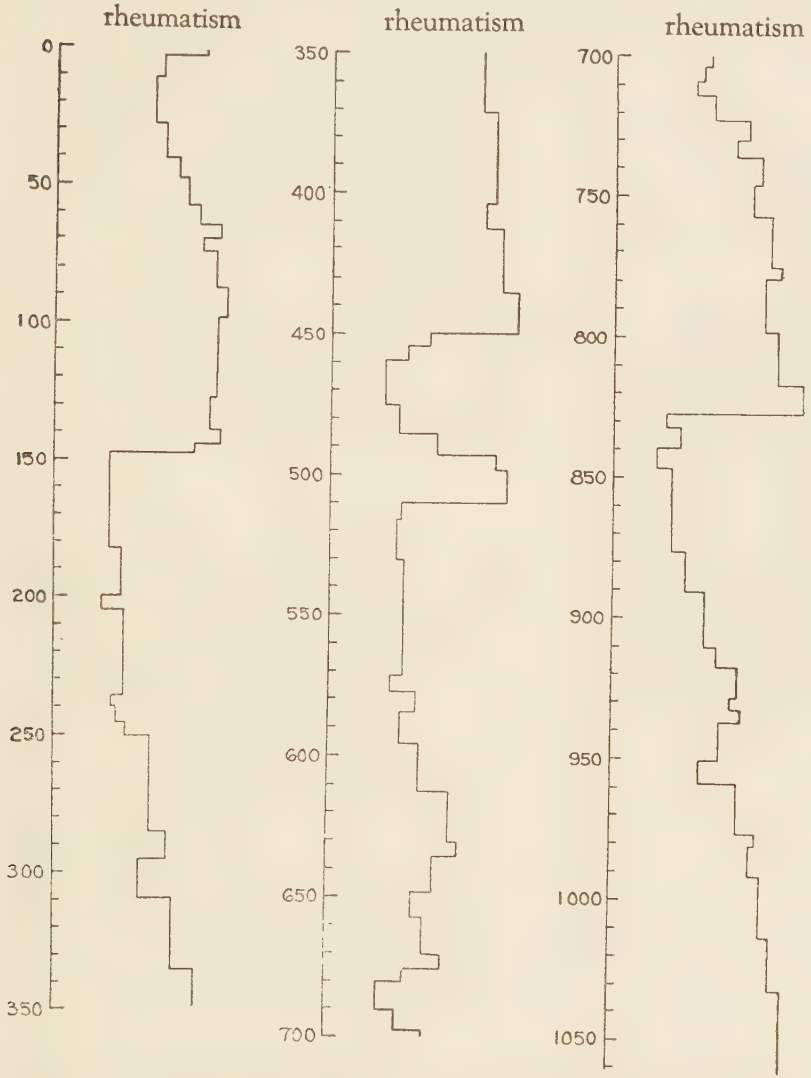


FIGURE 3. STUDY RECORD OF SUBJECT 16, A POOR SPELLER IN THE FOURTH GRADE. (The vertical axis shows the durations of the fixations in twenty-fifths of a second.)

quent regressions. He begins with a fixation near the end of the word, regresses only to the middle, then studies forward letter by letter, regressing again before reaching the end of the word. The second time across the pauses are, on the whole, much longer than before; nevertheless, four regressions appear. The third time across his procedure resembles that of more mature spellers; he made only four brief fixations with no regressions. On the fourth passage there is evidence of a detailed study of the middle part of the word. The last trip is characterized by short forward movements, long pauses and regressions. The entire procedure contrasts sharply with that of the mature speller of the college level.

These three cases serve to illustrate some of the differences in eye movement procedure which characterize varying degrees of maturity in learning to spell, and suggest the nature of the discussion to follow. Before proceeding to the analyses of the characteristic habits, the general data are presented.

Table of General Data

In Table IV the general data for all subjects are shown. The table gives the subject number, school grade, quality of spelling, the number of words missed on the fifty-word selection test, the average percentage of the required gain which was made, the average time per word, the average number of fixations per

TABLE IV

General Data for All Subjects

Subject	Grade	Quality	No. Words Wrong on 50 Word Test	Av. Per Cent Required Gain Made	Av. Time Per Word	Av. No. Fix'ns Per Word	Av. No. Fix'ns Per Letter	Av. Time Per Fixation	Av. No. Regressions Per Word
1	III	G	No Test	.70	245.4	22.	2.8	11.2	8.2
2	III	G	" "	.80	175.8	14.6	1.8	12.	5.
3	III	G	" "	.75	84.	7.4	.9	11.4	2.8
4	III	G	" "	.73	212.2	15.8	2.0	13.4	4.2
5	III	P	" "	.13	448.	32.4	4.1	14.	10.2
6	III	P	" "	.21	340.	26.2	3.3	13.	8.8
7	III	P	" "	.25	359.	30.	3.8	12.	8.
8	III	P	" "	.21	254.	20.4	2.6	12.5	5.4

TABLE IV (*Continued*)

Subject	Grade	Quality	No. Words Wrong on 50 Word Test	Av. Per Cent Required Gain Made	Av. Time Per Word	Av. No. Fix'ns Per Word	Av. No. Fix'ns Per Letter	Av. Time Per Fixation	Av. No. Regressions Per Word
9	IV	G	5	.80	243.2	22.6	2.	10.8	9.
10	IV	G	6	.35	307.2	32.4	2.8	9.5	9.4
11	IV	G	8	.70	190.2	20.	1.8	9.5	8.
12	IV	G	13	.30	381.4	35.	3.1	10.9	12.2
13	IV	P	47	.13	386.2	32.4	2.8	11.9	9.8
14	IV	P	49	.17	380.8	29.2	2.6	13.	8.2
15	IV	P	48	.04	331.8	37.	3.2	9.	15.6
16	IV	P	46	.09	812.	66.2	5.8	12.3	23.
17	V	G	1	.77	140.8	16.6	1.5	8.5	5.8
18	V	G	8	.89	268.	19.8	1.7	13.5	5.8
19	V	G	9	.74	161.4	15.	1.3	10.8	4.8
20	V	G	7	.69	95.8	10.2	.9	9.4	4.0
21	V	P	46	.22	672.	57.4	5.0	11.7	25.
22	V	P	46	.34	888.2	100.2	8.8	8.9	28.6
23	V	P	47	.07	504.2	42.2	3.7	11.9	12.6
24	V	P	48	.31	313.	29.4	2.6	10.6	6.4
25	VI	G	10	.67	149.	16.8	1.5	8.9	5.4
26	VI	G	2	.69	57.4	5.6	.5	10.3	2.8
27	VI	G	6	1.00	191.	16.2	1.4	11.8	6.2
28	VI	G	5	.90	202.6	21.	1.8	9.6	6.2
29	VI	P	42	.39	565.2	58.	5.1	9.7	18.
30	VI	P	45	.36	741.2	63.6	5.6	11.7	16.2
31	VI	P	45	.20	429.2	35.	3.1	12.3	10.6
32	VI	P	49	.13	276.8	25.4	2.2	10.9	8.
33	Sf.	G	9	.55	136.8	16.	1.4	8.6	5.2
34	Sf.	G	8	.75	290.	28.2	2.4	10.3	10.8
35	Sf.	G	12	.31	152.6	17.4	1.5	8.8	3.8
36	Sf.	G	12	.80	119.2	13.8	1.2	8.6	5.8
37	Sf.	P	45	.45	594.6	54.4	4.6	10.9	16.8
38	Sf.	P	46	.33	528.4	51.8	4.4	10.2	18.4
39	Sf.	P	47	.33	516.6	50.8	4.3	10.2	16.8
40	Sf.	P	47	.51	540.2	62.8	5.3	8.6	19.8
41	Fr.	G	2	.76	165.	18.2	1.5	9.1	5.8
42	Fr.	G	3	.86	158.2	17.4	1.5	9.1	5.8
43	Fr.	G	6	.66	184.	22.4	1.9	8.2	4.6
44	Fr.	P	47	.20	755.2	73.	6.2	10.3	27.2
45	Fr.	P	44	.63	450.8	47.8	4.1	9.4	14.4
46	Fr.	P	41	.40	423.	38.2	3.2	11.1	13.
47	So.	G	3	1.00	178.8	22.8	1.9	7.9	7.4
48	So.	G	5	.43	105.8	10.8	.9	9.8	4.2
49	So.	G	5	.68	165.2	20.4	1.7	8.1	4.8

TABLE IV (*Continued*)

Subject	Grade	Quality	No. Words Wrong on 50 Word Test	Av. Per Cent Required Gain Made	Av. Time Per Word	Av. No. Fix'ns Per Word	Av. No. Fix'ns Per Letter	Av. Time Per Fixation	Av. No. Regressions Per Word
50	So.	P	39	.43	274.4	26.4	2.2	10.4	7.4
51	So.	P	38	.32	231.	26.2	2.2	8.8	6.8
52	So.	P	37	.25	303.2	36.2	3.1	8.4	11.8
53	Jr.	G	3	.80	104.	13.8	1.2	7.5	4.4
54	Jr.	G	4	.81	146.6	15.6	1.3	9.4	4.4
55	Jr.	G	4	.86	109.2	13.8	1.2	7.9	3.6
56	Jr.	P	29	.49	411.2	37.8	3.2	10.9	13.8
57	Jr.	P	36	.17	356.4	32.6	2.8	10.9	9.2
58	Jr.	P	29	.48	390.2	39.4	3.3	9.9	12.
59	Sr.	G	1	.94	127.6	14.8	1.3	8.6	4.4
60	Sr.	G	2	.76	124.	14.4	1.2	8.6	3.8
61	Sr.	G	2	1.00	105.	12.2	1.	8.6	5.2
62	Sr.	P	33	.19	212.2	23.8	2.	8.9	6.
63	Sr.	P	24	.45	210.2	21.6	1.8	9.7	7.2
64	Sr.	P	22	.08	316.	28.8	2.4	11.	8.6
65	Col.	G	0	1.00	51.	6.2	.5	8.2	1.4
66	Col.	G	0	1.00	43.2	5.8	.5	7.4	2.2
67	Col.	G	No Test	1.00	50.2	6.8	.6	7.4	2.8

word, the average number of fixations per letter, the average duration of the fixations and the average number of regressions per word. Time is expressed in twenty-fifths of a second. This table is intended only for reference, the summaries being given in later tables.

The Number of Fixations

The first outstanding difference in the records of the good and poor spellers lies in the number of fixations. Table V shows the average number of fixations per word for the good and poor spellers of the third grade. The table indicates a marked

TABLE V

Average Number of Fixations Per Word—Third Grade

Subjects	Third Grade
Good Spellers	15.
Poor Spellers	27.3
Good and Poor	21.2

superiority of the good spellers, their average being only 55 per cent of that of the poor spellers.

Table VI shows the average number of fixations per word for the fourth, fifth and sixth grades, both by school year and by

TABLE VI

Average Number of Fixations Per Word—Fourth, Fifth and Sixth Grades

	Grade			
Subjects	Fourth	Fifth	Sixth	Average for All
Good Spellers	27.5	15.4	14.9	19.3
Poor Spellers	41.2	57.3	45.5	48.
Good and Poor	34.4	36.4	30.2	33.7

quality of spelling. In each of these grades the good spellers use fewer fixations than the poor spellers. The average for all the good spellers is only 40 per cent of the average for all the poor spellers.

Table VII shows the average number of fixations per word for the three adult good spellers and thirty-two good and poor

TABLE VII

Average Number of Fixations Per Word—High School and Adult Subjects

	Grade					
Subjects	Subfr.	Fresh.	Soph.	Junior	Senior	Coll.
Good Spellers	18.9	19.3	18.	14.4	13.8	6.3
Poor Spellers	55.	53.	29.6	36.6	24.7	
Good and Poor	37.	36.2	23.8	25.5	19.3	

spellers of the high school. As in the elementary school, the poor spellers at every level in high school employ more fixations than do good spellers.

Figure 4 presents graphically the data of Table VI. The figure shows a decrease in the average number of fixations for the good spellers from grade to grade. For the poor spellers the curve is irregular, starting low at the fourth grade. The fourth grade poor spellers averaged but a small percentage of the improvement which they needed for the perfect spelling of the words of Set Two. Their average percentage of the required gain was only .11, whereas that for the fifth grade poor spellers was .24 and that for the sixth grade poor spellers was .27. There is nothing in

the data to explain with certainty the reason for the relatively short study and few fixations of the poor fourth grade group; fluctuation of attention may be responsible, or perhaps lack of judgment as to the amount of accomplishment. The poor fifth grade spellers average a larger number than the poor fourth grade; the phenomenon possibly reflects an additional year's train-

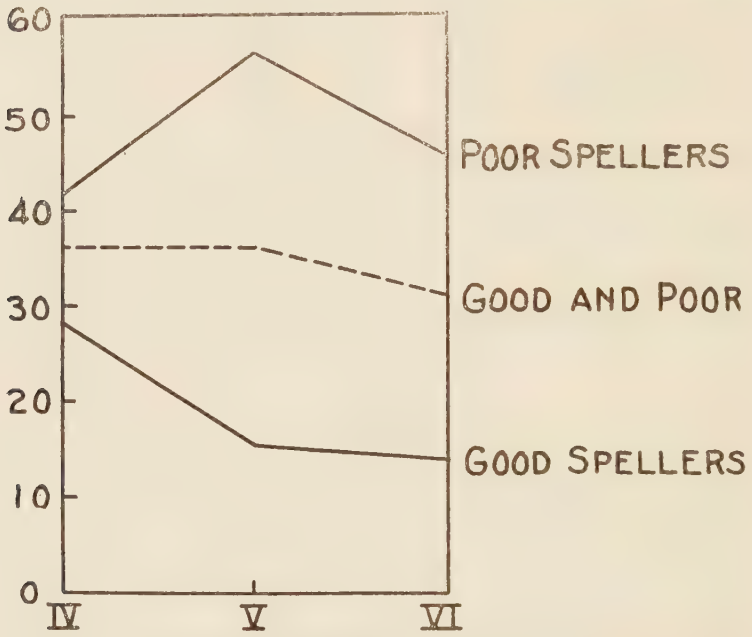


FIGURE 4. AVERAGE NUMBER OF FIXATIONS—FOURTH, FIFTH AND SIXTH GRADE SUBJECTS. (The numbers on the vertical axis indicate fixation averages.)

ing in "going over the word" and "keeping at work". The curve shows a drop at the sixth grade; nevertheless, the position here is somewhat higher than that of the fourth grade. The data indicate very clearly that for the latter grades of the elementary school the number of fixations for the good spellers tends to decrease year by year, while the number of fixations for the poor spellers shows a slight tendency to increase. The explanation is probably as follows: the good spellers are given no special help, and their increasing familiarity with words of a

given level of difficulty is naturally accompanied by a decrease in the number of their fixations; the poor spellers, on the other hand, are singled out for special attention. The special attention is apt to take the form of increase in the amount of study; the child is urged to look at the word again and again until he knows it; it is natural for him to form the habit of long study.

Figure 5 presents graphically the data of Table VII. For the poor spellers of the high school the curve assumes a downward slant. It is broken by a peak at the junior level due to an unduly

FIGURE 5. AVERAGE NUMBER OF FIXATIONS—HIGH SCHOOL AND COLLEGE SUBJECTS. (The numbers on the vertical axis indicate fixation averages.)

low position of the sophomore poor spellers and is probably explained, in part at least, by the relatively small amount of gain made by the latter group during the study period before the camera. The sophomore poor spellers averaged 8 per cent less gain than the freshman poor spellers and 5 per cent less gain than the junior poor spellers. The curve for the good spellers shows steady year to year growth with but one very slight rise in an otherwise downward sloping line.

These data are interesting in view of the fact that no systematic study of spelling is required in the high school. The smallest number of fixations was made by the adult good spellers, proving clearly that development along this line may take place without benefit of special instruction.

The analysis indicates that for good spellers growth takes place from year to year in the elementary school and the high school and even during the college years. It would appear that the manner and amount of study adopted by the good speller in the early stages of mastering spelling are adequate to his needs, that he profits by continued experience in spelling situations, that his increasing familiarity is manifested, in part at least, by a decrease in the amount of study, as indicated by the number of fixations.

The poor speller, making unsatisfactory progress at first and attempting to correct his deficiency, increases the amount of his study, with the result that during the last two years of the elementary school the number of fixations employed is greater than in the fourth grade. After reaching the high school, he tends to decrease the amount of his study; this may reflect impatience or it may reflect a certain degree of familiarity with words.

Order of Fixations

The pattern which characterizes typical records of eye behavior in learning to spell words is the left-to-right survey or passage across the word in a series of predominantly forward movements. No record indicates that the procedure was chiefly of a disorganized, random variety with fixations scattered here and there in unrelated fashion. While some records give evidence of considerable part by part study it is almost invariably subordinate to the study by surveys of the whole.

It is usually true that the more mature the speller the less often the cross passage is repeated. To illustrate, the surveys for the word *autochthonous* have been identified and the data are presented in Table VIII. At every level the good spellers averaged

TABLE VIII

Average Number of Passages Across the Word Autochthonous—*High School and College Subjects*

	Grade					
Subjects	Subfr.	Fresh.	Soph.	Junior	Senior	Coll.
Good Spellers	2.7	2.5	2.3	2.2	1.7	1.
Poor Spellers	5.2	5.	3.6	3.6	2.3	
Good and Poor	4.	3.8	3.	2.9	2.	

fewer of these basic patterns than did the poor spellers. Further, there is an almost uninterrupted grade to grade decrease for both good and poor; the good spellers at each level show improvement over the good spellers of the preceding level; similar growth is evident for the poor spellers with the single exception of the juniors who averaged the same as the sophomores.

The span or extent of these surveys varies. Some students proceed to the very ends of the word with their fixations, others limit their ranges to something less than the total width of the word. To a great extent this variation is due to differences in the sizes of the recognition ranges. But in addition, there are individual variations of procedure with respect to the same word. Occasionally a record shows fixations falling beyond the limits of the word; the phenomenon is confined, however, almost entirely to the long records of the immature spellers.

Table IX shows the average number of repetitions of the left-to-right survey pattern made by the good and poor spellers of the fourth, fifth and sixth grades, in learning to spell *conscientious*. This word has the same length as *autochthonous*.

TABLE IX

Average Number of Passages Across the Word Conscientious—*Fourth, Fifth and Sixth Grades*

Subjects	Grade			
	Fourth	Fifth	Sixth	All
Good Spellers	3.4	2.4	2.5	2.8
Poor Spellers	2.3	5.8	5.2	4.4
Good and Poor	2.9	4.1	3.9	3.6

The fourth grade poor spellers average fewer repetitions of the pattern than do good spellers of the same grade, but this irregularity is explained by the failure of the former group to make an appreciable gain. These pupils stopped studying too soon; they are likewise responsible for an irregularity in the tables and growth curves covering the number of fixations. In the fifth and sixth grades, however, the poor spellers go over the word more than twice as often as the good spellers. Allowing for the aberration of the poor fourth grade group, some growth is evident for both good and poor spellers.

Table X shows the average number of left-to-right passages over the word *quarantine* for the good and poor groups of the third grade. As with the older pupils, the poor spellers repeat the pattern more often than do the good spellers.

TABLE X

Average Number of Passages Across the Word Quarantine—*Third Grade*

Subjects	Third Grade
Good Spellers	2.3
Poor Spellers	3.5
Good and Poor	2.9

Figures 6a, 7a, 7b, 8a, 8b, 9a, 9b, 10a and 10b present graphically the study procedures for two words each of nine subjects of different grade levels. The records illustrate the manner in which the passages are made and repeated.

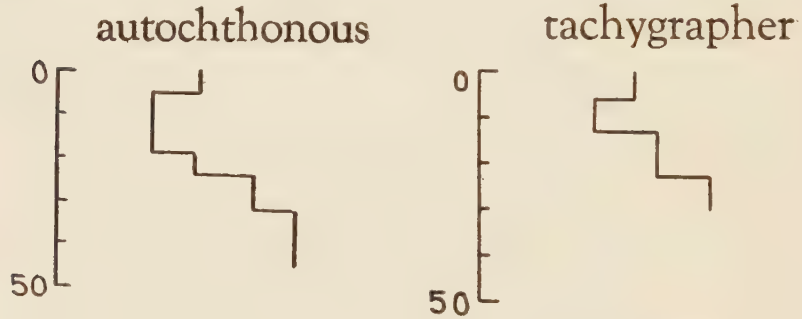


FIGURE 6a. TWO RECORDS OF SUBJECT 65, GOOD ADULT SPELLER

Inspection of the figures reveals two features of particular interest. First, the study patterns of the same individual tend to resemble one another. Subject 65 (Figure 6a) begins both records with a fixation near the middle of the word, moves back toward the first part of it, then progresses to the right with steplike regularity. The two records of subject 57 (Figure 7b) are alike in their very irregularity; both exhibit long and short moves, long and short pauses, regressions. Subject 43 (Figure 8a) may be identified by the systematic progression with even pauses and movements. Subject 45 (Figure 8b) tends to complete the pattern with a final long movement to the right for an unusually short pause. And so on.

Second, these figures illustrate how the contours of the cross study patterns vary with maturity. With immature spellers the pattern is apt to be irregular with frequent regressions and with varying lengths of movements and pauses. On the whole the movements tend to be short and the pauses tend to be long. The

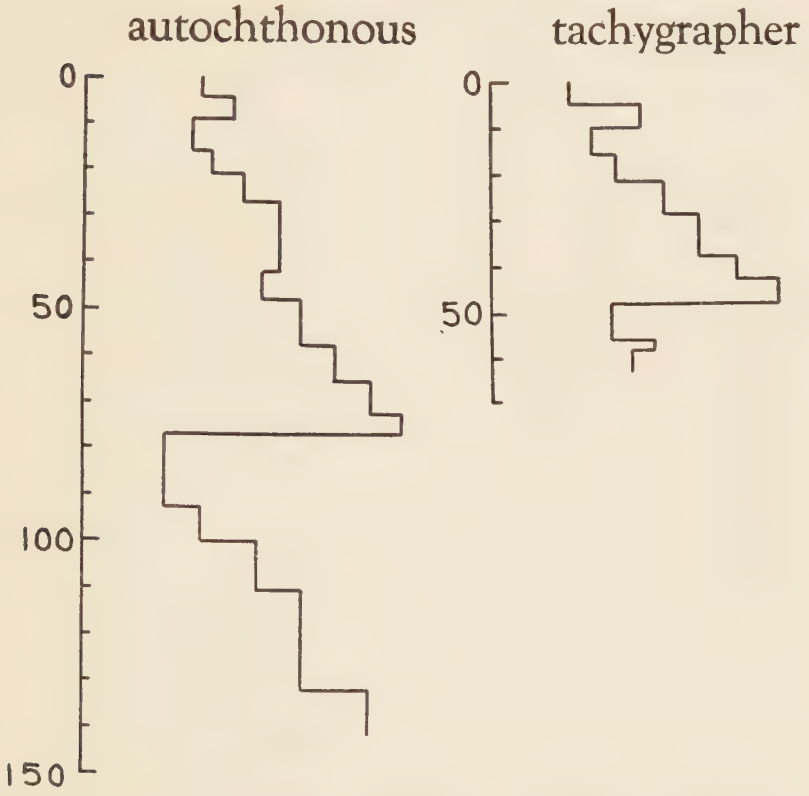


FIGURE 7a. TWO RECORDS OF SUBJECT 55, GOOD SPELLER, JUNIOR YEAR

fundamental pattern is repeated, typically with variations each time. As maturity in spelling increases the number of cross study passages decreases and their regularity increases. Regressions within the pattern tend to disappear and the fixation times take on a greater evenness, so that the record when pictured in graphic form, resembles sets of steps, one above another. With complete maturity, however, this resemblance breaks down. The pattern is not repeated and the total number of fixations de-

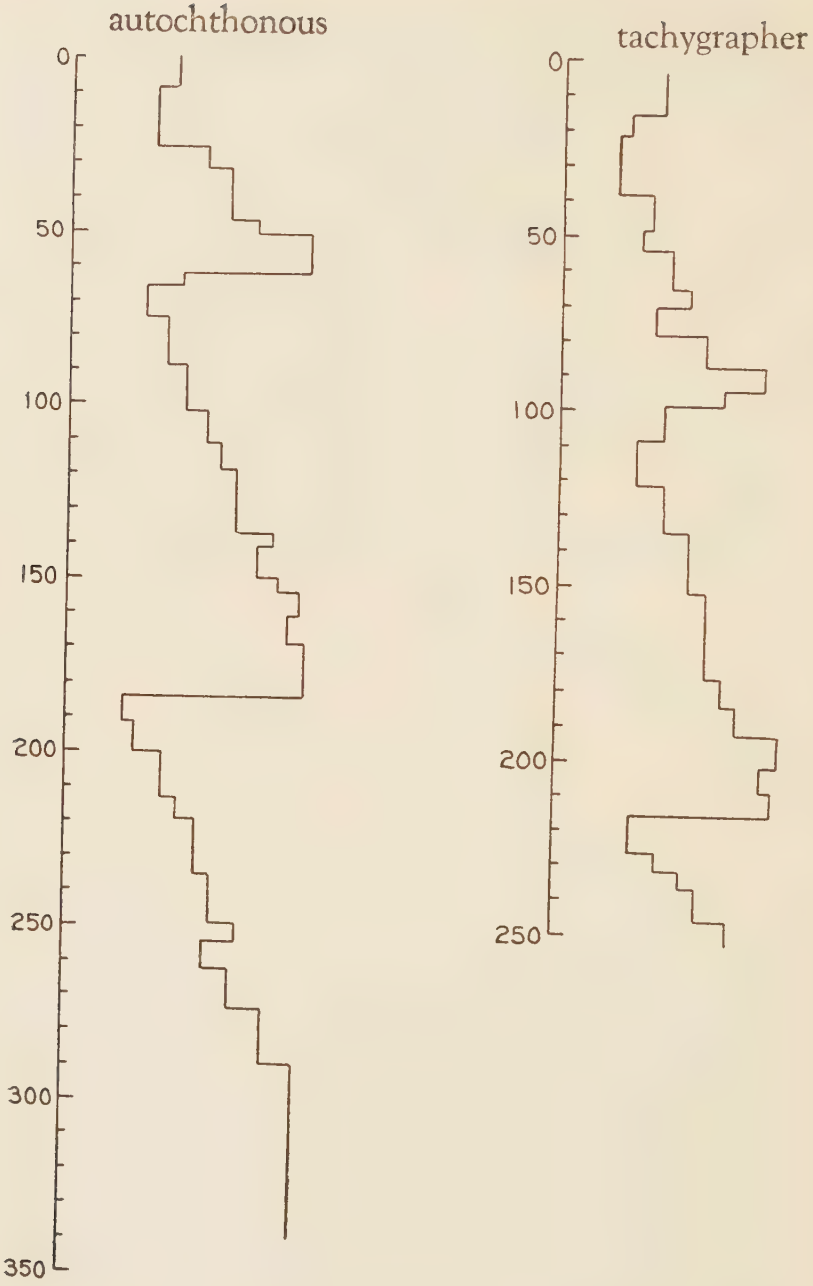


FIGURE 7b. TWO RECORDS OF SUBJECT 57, POOR SPELLER, JUNIOR YEAR

creases to an average of one to every two letters: the sets of steps are telescoped into three or four movements.

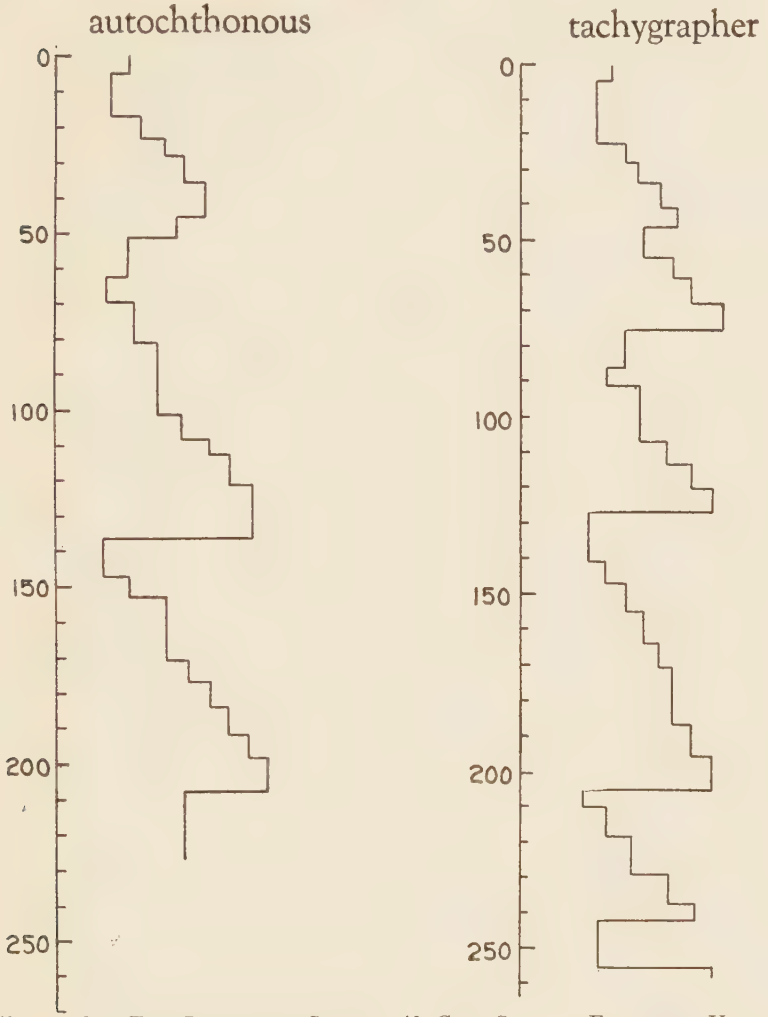


FIGURE 8a. TWO RECORDS OF SUBJECT 43, GOOD SPELLER, FRESHMAN YEAR

These illustrations are intended only to suggest in a general way the nature of the chief differences between the cross passages of good and poor, mature and immature spellers. More detailed attention is paid to the significant features in the summary sections of the study.

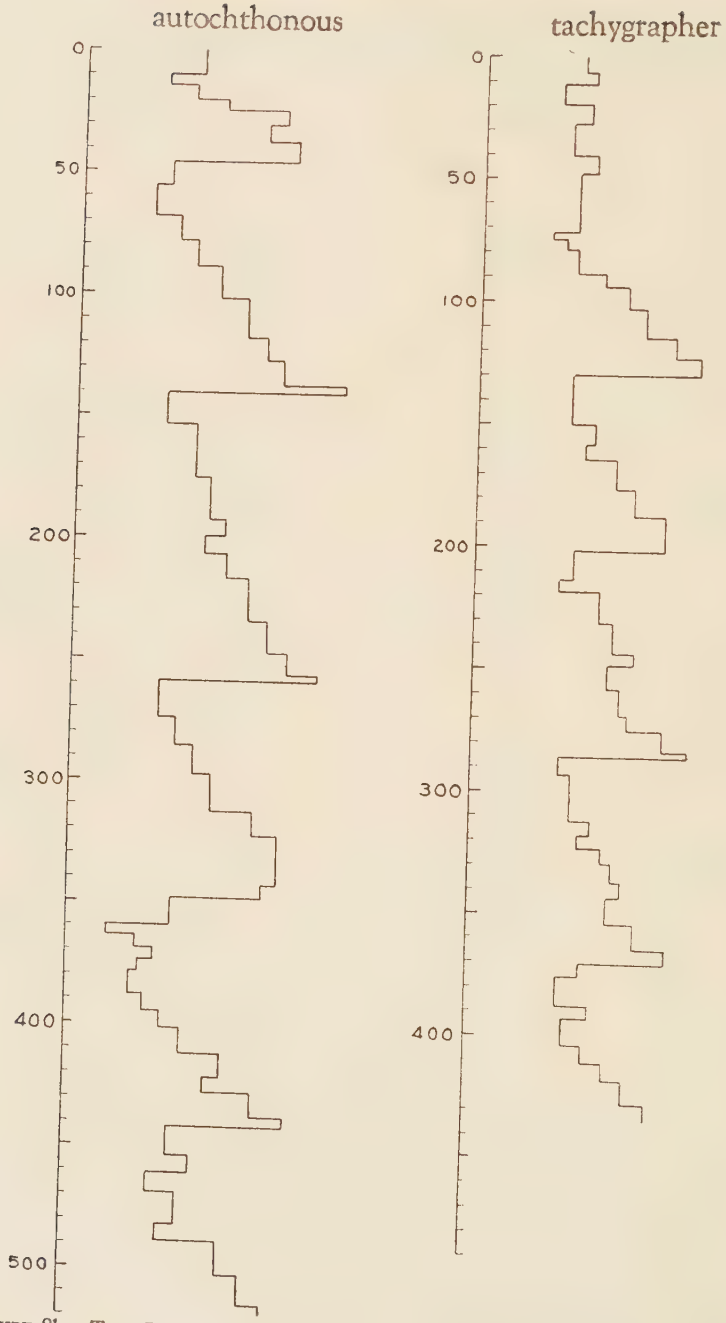


FIGURE 8b. TWO RECORDS OF SUBJECT 45, POOR SPELLER, FRESHMAN YEAR

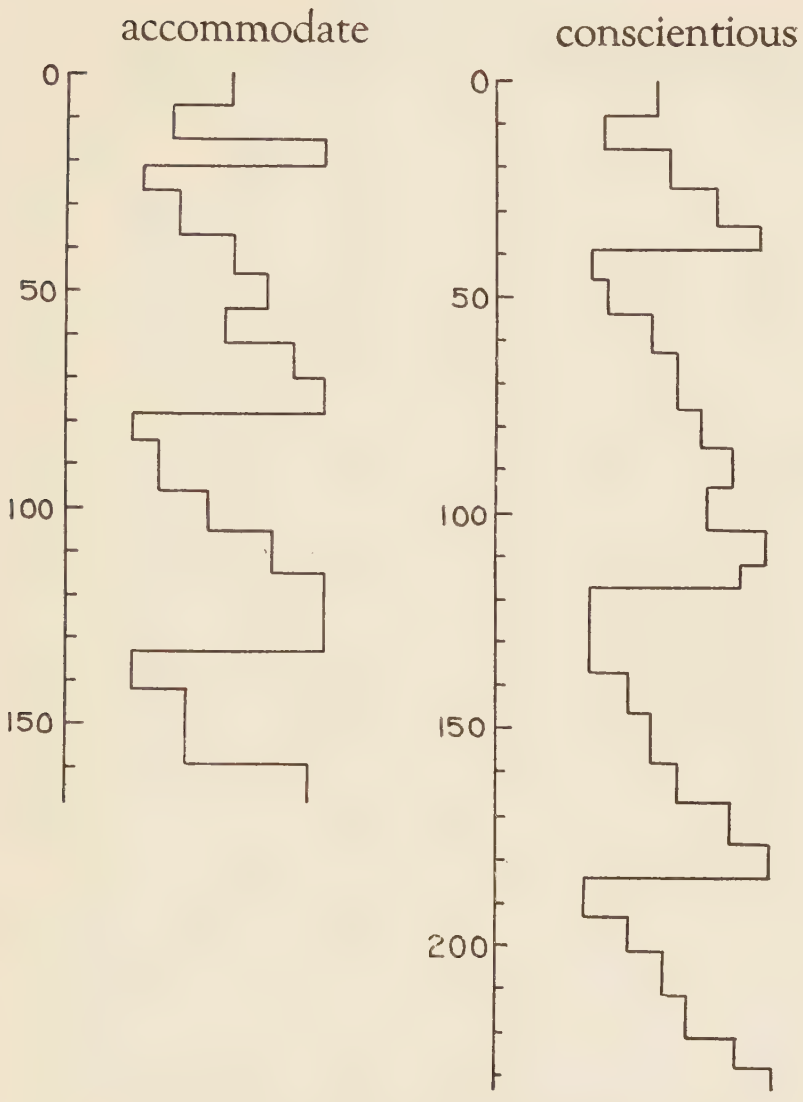


FIGURE 9a. TWO RECORDS OF SUBJECT 28, GOOD SPELLER, SIXTH GRADE

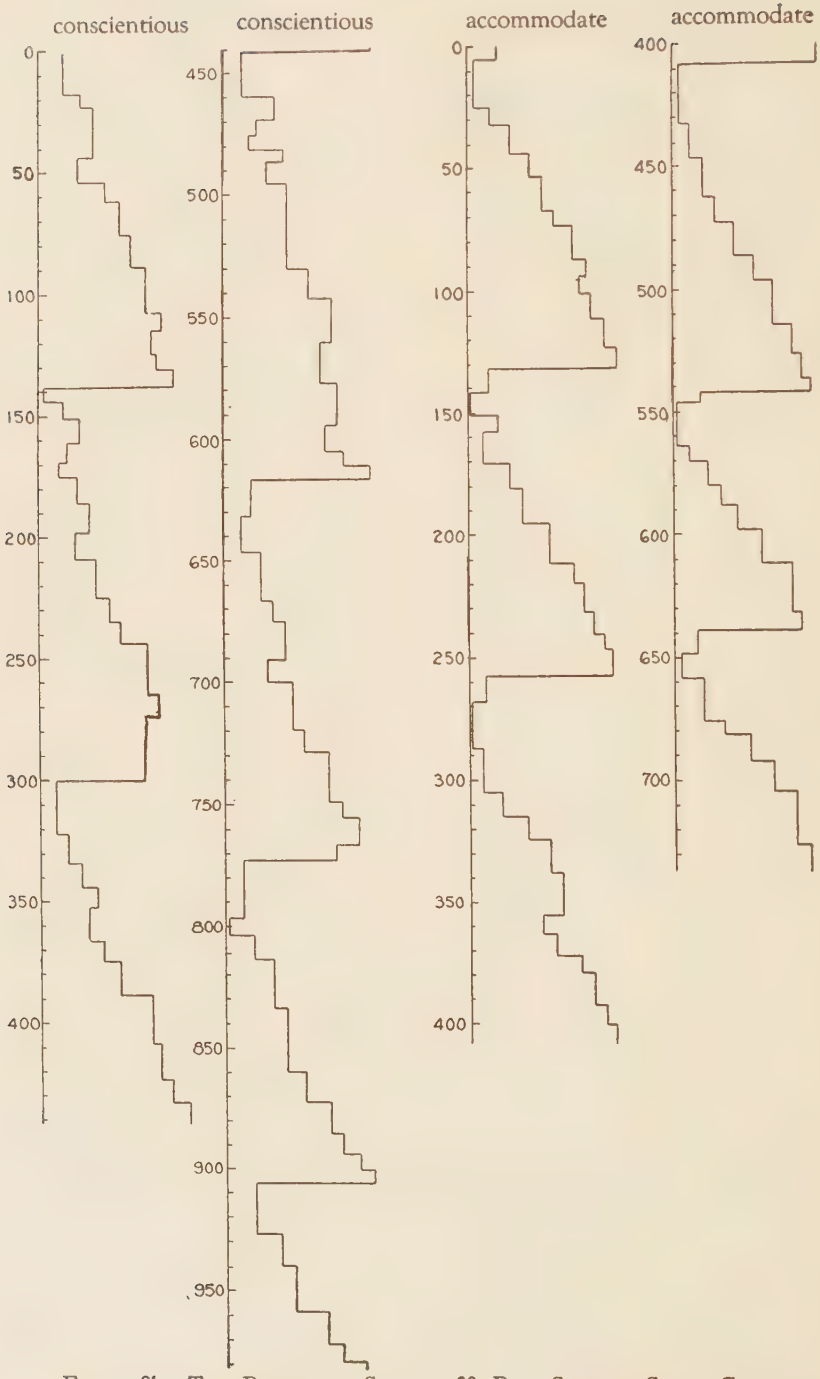


FIGURE 9b. TWO RECORDS OF SUBJECT 30, POOR SPELLER, SIXTH GRADE

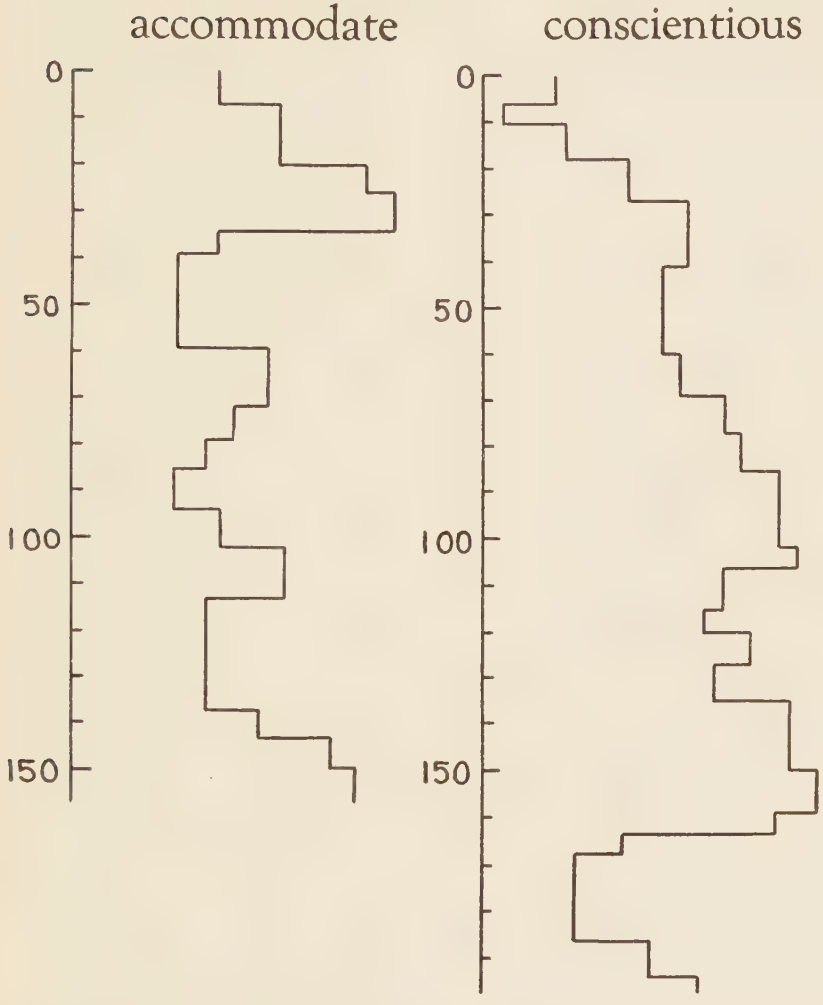


FIGURE 10a. TWO RECORDS OF SUBJECT 11, GOOD SPELLER, FOURTH GRADE

FIGURE 10b. TWO RECORDS OF SUBJECT 16, POOR SPELLER, FOURTH GRADE

Between the cross study patterns which characterize the spelling records there may be one or more of several phenomena. There may be the long backward sweep of the eye (Fig. 11a) to a point from which to begin the cross study anew. Here and there a subject fails to attain an advantageous position in a single backward sweep (Fig. 11b) and is forced to make an additional regression. Some students connect their forward cross study patterns by series of right-to-left shifts (Fig. 11c) with intervening pauses of such length as to suggest backward study.

Sometimes there occurs between cross passages a group of pauses limited to a narrow section of the word in such a manner (Fig. 11d) as to indicate repeated attention to a part of the word. Now and then a record shows a return sweep backward from the conclusion of a passage (Fig. 11e) then a return sweep to the right, and then a long regression. This may represent an oscillating unsystematic type of behavior, or it may be a return for verification, or perhaps may result from a momentary fluctuation of attention. No method suggests itself for determining the point with certainty. The phenomenon occurs but rarely and then only in the long records of the more immature subjects.

Very frequently the study does not begin with the first fixation of the first left-to-right survey passage. The initial fixation typically falls at some midway point. This may be due to the preliminary technique in the photographing which necessitated fixating a dot above the last letter of the word just before beginning study. Preliminary fixation first on a dot at the right and then on a dot at the left proved unsatisfactory since, in plotting, it was sometimes impossible to identify the actual commencement of study. Or it may be due to the fact that people have learned to look at the middle of words. The phenomenon is frequently found in reading records and may carry over to spelling.

Here and there at all levels, after this initial midway fixation, occasional records show a long sweep to the right, and then a regression to begin the cross study. This may indicate that an initial pre-view of the word has taken place or may be simply a

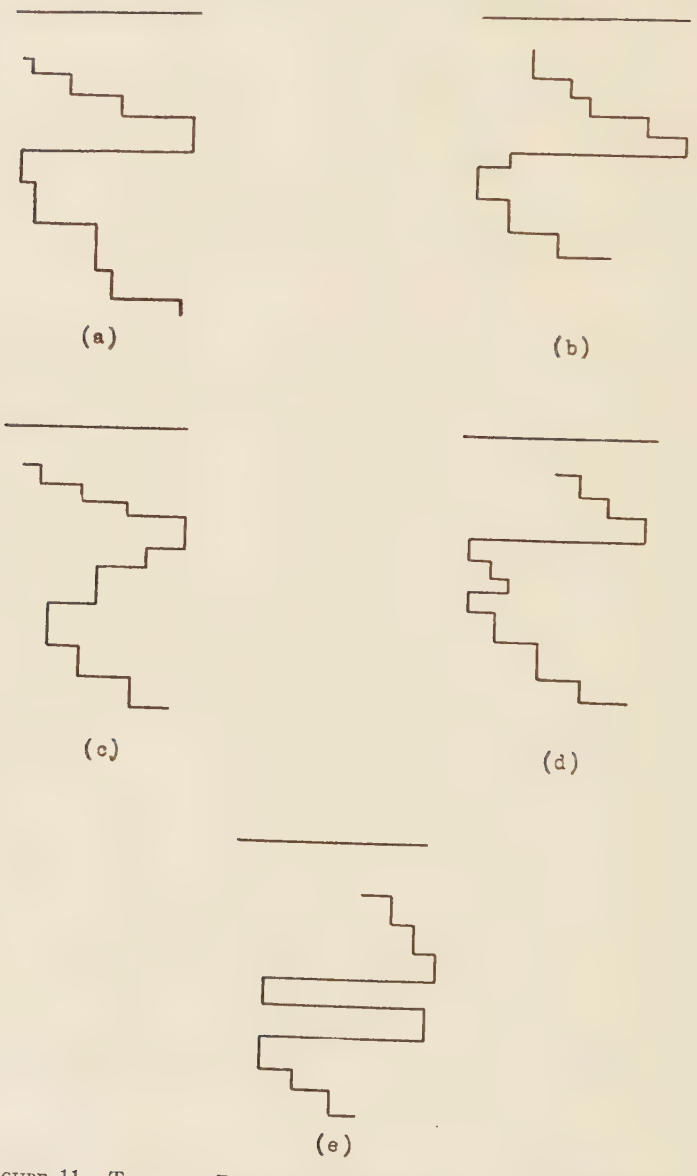


FIGURE 11. TYPES OF PHENOMENA WHICH MAY OCCUR BETWEEN SUCCESSIVE FORWARD PASSAGES ACROSS A WORD

random movement of the eye in making its accommodation. (See Figure 9a, *accommodate.*) There are occasional instances of repeated study of a section of the word before the first cross study begins. (Figure 10b, *conscientious.*)

The data show that the study may end with the final fixation of one of the typical cross passages or with certain accessory fixations similar to those occurring between the basic patterns or before the initial pattern. That is, there may be a regressive study, or a final repeated study of a part, or one or more sweeping shifts back and forth. (See Figure 8, *tachygrapher.*) Except that mature spellers do not tend to give much detailed, repeated attention to parts of a word, there appears to be no close relationship between the manner of beginning study, connecting cross study patterns, or concluding study and the degree of maturity of the subject.

The analysis of the number of repetitions of the cross survey used by the subjects of the various levels amplifies the findings of the preceding section. The total number of fixations is greater for the poor spellers than the good, greater for the immature than the mature. This is partly brought about by the greater frequency of repetitions of the cross passage over the word. With the subjects used in this investigation poor progress in spelling can not be attributed to laziness. The poor speller goes over the word more often than does the more successful one, but his effort is less effectual.

Study Time per Word

In general the good spellers spent less time studying before the camera than did the poor spellers, and mature spellers spent less time than those who were less mature. Table XI gives the average time per word for the good and poor spellers of the third

TABLE XI

Average Time Per Word—Third Grade

Subjects	Third Grade
Good Spellers	179.4
Poor Spellers	350.3
Good and Poor	264.9

grade. The good spellers studied only 51 per cent as long as the poor spellers.

Table XII gives the average time per word for the good and poor spellers using the words of Set Two, that is, the fourth, fifth and sixth grades. The superiority of the good spellers is marked in all three grades. The average for all the good spellers is only 38 per cent of that for all the poor spellers.

TABLE XII

Average Time Per Word—Grades Four, Five and Six

Subjects	Grade			
	Fourth	Fifth	Sixth	All
Good Spellers	280.5	166.5	150.	199.
Poor Spellers	477.7	594.4	503.1	525.1
Good and Poor	379.1	380.5	326.6	362.1

Figure 12 brings out a grade to grade decrease for the good spellers. For the poor spellers, the time of the fifth grade pupils exceeds that of the fourth grade pupils. This phenomenon possibly reflects the poor relatively short experience of the fourth grade subjects in the formal study of spelling. They have not

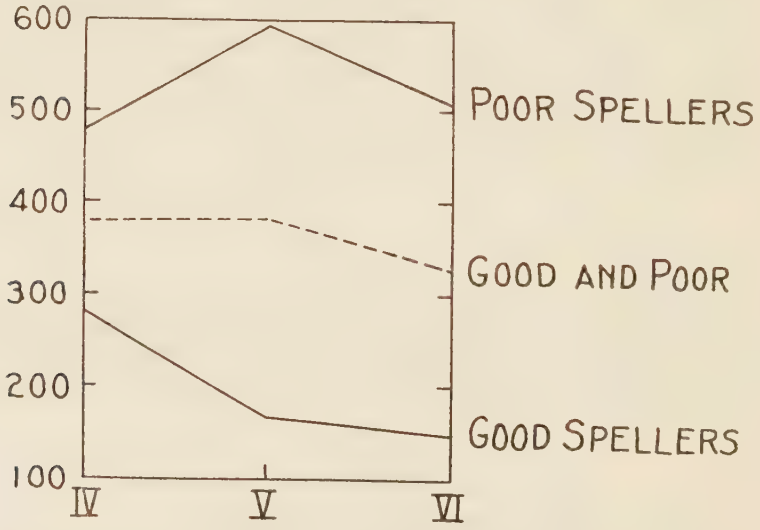


FIGURE 12. AVERAGE TIME PER WORD—FOURTH, FIFTH AND SIXTH GRADES. (Time indicated by the vertical axis and expressed in twenty-fifths of a second.)

yet acquired to any extent the attitude of going over and over the word "until they know it". By the fifth grade the habit of long study reaches its peak; thereafter comes a decline.

Table XIII presents the data for the high school and college subjects. The study time of the good spellers is shorter than that of the poor spellers in every year where comparison is possible.

TABLE XIII

Average Study Time Per Word—High School and College Subjects

	Grade					
Subjects	Subfr.	Fresh.	Soph.	Junior	Senior	College
Good Spellers	174.7	169.1	149.9	119.9	118.9	48.1
Poor Spellers	545.	543.	269.5	385.9	246.1	
Good and Poor	359.9	356.1	209.7	252.9	182.5	

Figure 13 shows a gentle, unbroken downward slope for the good spellers. For the poor spellers the curve is less regular. The sophomores exhibit an unusually short study period: their pseudo-maturity is discussed in some detail in sections dealing with the number and duration of fixations. It would appear that improvement in shortening study time proceeds at a more rapid rate with poor spellers than with good, but the phenomenon must be discounted to some extent since the good spellers improve their learning efficiency from year to year, while the poor spellers in

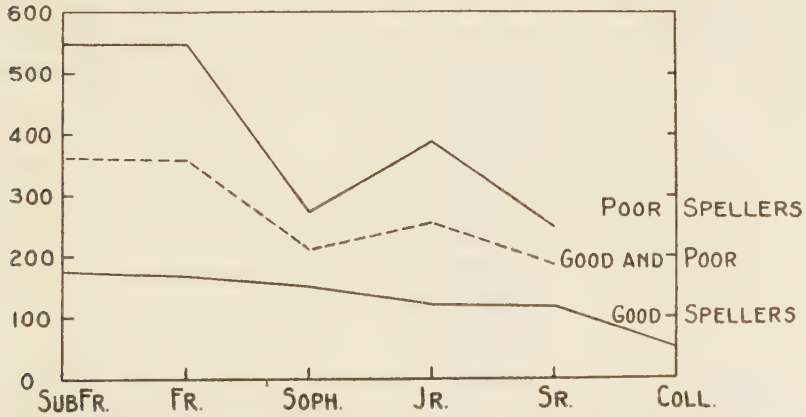


Figure 13. Average Time Per Word—High School and College Subjects. (Time is indicated by the vertical axis and is expressed in twenty-fifths of a second.)

the high school are irregular in the amount of their improvement. Despite irregularities, however, the downward trend of the curve indicates clearly a tendency on the part of poor spellers in the high school to decrease their time of study from year to year.

Reference to the general data table shows that at every level the amount of the required gain made by the good spellers greatly exceeds that of the poor spellers. Except in the subfreshman year, no individual poor speller at any level surpassed any good speller of the same level in the amount of improvement. It follows logically that a high negative relationship exists between learning efficiency and the length of the study period.

Mothers of slow learners and teachers have frequently voiced the opinion that the slow student is the successful student. While it is doubtless true that some pupils fail to achieve greatly because of superficiality, the results here reported indicate that on the whole slowness in learning spelling does not beget sureness. The efficient learner is the quick learner.

Duration of Fixations

The introductory case descriptions indicated briefly that good and poor spellers differ with respect to the length of fixations and that definite growth is discernible through the grades. This section considers the matter in greater detail. Table XIV presents the data for the third grade. Even in this grade the good spellers are briefer in their pauses than are the poor spellers.

TABLE XIV

Average Duration of Fixations—Third Grade

(Time is expressed in twenty-fifths of a second.)

Subjects	Third Grade
Good Spellers	12.
Poor Spellers	12.9
Good and Poor	12.5

Table XV presents the data for the good and poor spellers of the fourth, fifth and sixth grades. Some superiority is evident for the good spellers at each of these levels, but is most marked

TABLE XV

AVERAGE DURATION OF FIXATIONS—FOURTH, FIFTH AND SIXTH GRADES

(Time is expressed in twenty-fifths of a second.)

Subjects	Grade		
	Fourth	Fifth	Sixth
Good Spellers	10.2	10.6	10.2
Poor Spellers	11.6	10.8	11.2
Good and Poor	10.9	10.7	10.7

in the sixth grade. This finding differs from that of Abernethy (see p. 4) whose records showed the poor spellers at this level somewhat the briefer in pause duration.

Table XVI presents the data for the high school and college subjects. As in the elementary school, the good spellers make shorter fixations than the poor spellers at every level.

TABLE XVI

AVERAGE DURATION OF FIXATIONS—HIGH SCHOOL AND COLLEGE GROUPS

(Time is expressed in twenty-fifths of a second.)

Subjects	Grade					
	Subfr.	Fresh.	Soph.	Junior	Senior	College
Good Spellers	9.1	8.8	8.8	8.3	8.6	7.7
Poor Spellers	10.	10.3	9.2	10.6	9.9	
Good and Poor	9.6	9.6	9.0	9.5	9.3	

Figure 14 presents the data of Table XV in graphic form. For both good and poor spellers the curve is irregular. For the

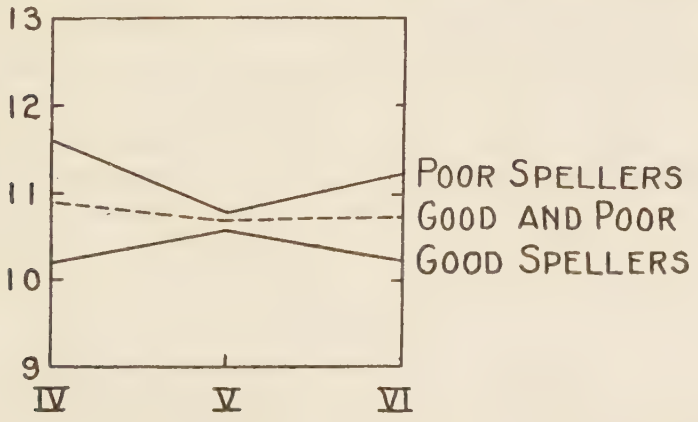


FIGURE 14. AVERAGE FIXATION TIME—FOURTH, FIFTH AND SIXTH GRADES. (Duration of fixations is indicated on vertical axis; school grade is shown on horizontal axis.)

good spellers the peak occurring at the fifth grade appears to result from an unduly low position for the fourth rather than from any irregularity of the fifth grade itself. The good fourth grade spellers used somewhat shorter fixations than might have been expected. However, they realized only 54 per cent of the gain which was necessary for perfect learning, whereas the fifth grade good spellers averaged 77 per cent and the sixth grade good spellers averaged 82 per cent; even the third grade good spellers surpassed them with 77 per cent of their required gain.

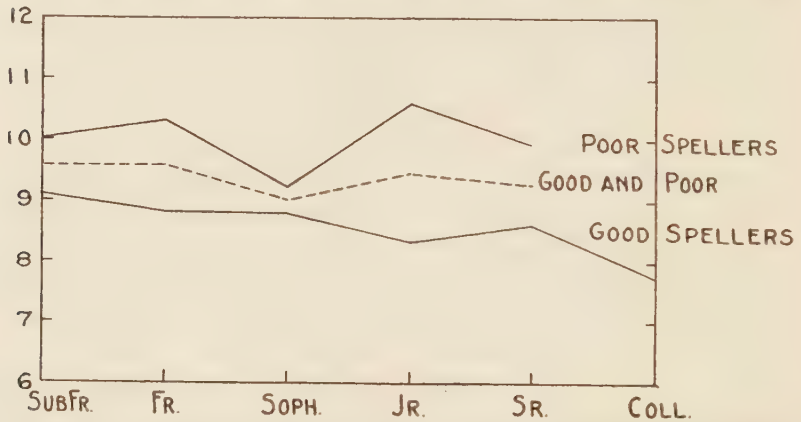


FIGURE 15. AVERAGE FIXATION TIME—HIGH SCHOOL AND COLLEGE SUBJECTS. (Duration of fixations is indicated on vertical axis; school grade is shown on horizontal axis.)

The position of the sixth grade is approximately the same as that of the fourth.

For the poor spellers the curve shows a slight rise at the sixth grade. Nevertheless, both fifth and sixth grades claim lower positions than the fourth grade. Apparently even in the elementary school there is some indication of a tendency to shorten the fixations year by year.

Figure 15 presents graphically the data of Table XVI. Growth for the good spellers is more regular in the high school than in the elementary school. Barring a minor rise at the senior level, the decrease in fixation time continues steadily. At least as much progress is made during the college years as during the high school period.

The curve for the poor spellers is irregular. The highest peak occurs at the junior level and is rather difficult to account for; it so happened that all of the members of this group studied unusually long, employing many protracted fixations. The depression in the curve for the sophomores no doubt is related to the small percentage of gain made by this group. It is evident from all the growth curves that poor spellers are less even and consistent in their development than are good spellers. The good spellers without formal instruction in spelling continue to cut down their fixation time during the high school and college years nearly one and one-half twenty-fifths of a second. The irregularity of the poor speller's curve suggests that beyond the freshman year decrease in pause time is a matter of chance.

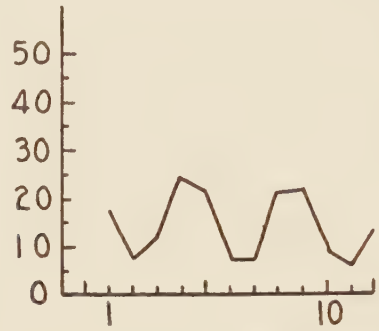
These facts serve to extend the findings discussed in previous sections. In other words, the long study time of the poor speller is affected not only by the multiplicity of his fixations but also by their duration.

Since the "good spellers" of this investigation proved also to be more efficient learners, the negative relationship between efficiency and length of pause is obvious. Young children encountering new symbols study slowly, third grade pupils pausing almost twice as long as college students. The prolonged scrutiny overcomes in greater or less measure the learner's strangeness in spelling situations. Letters and letter combinations begin to assume a familiar look and meaning. Gradually the rate of perception speeds up. Since good spellers surpass poor spellers in acquiring this familiarity, the good spellers surpass the poor in the amount and consistency of their development along this line.

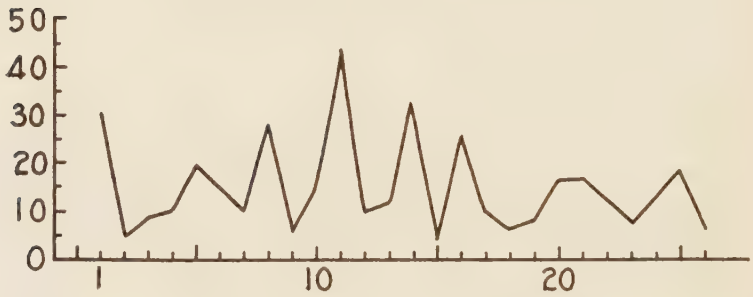
Uniformity of Fixation Lengths

Inspection of the graphic study records has shown that good spellers are more regular in their eye movement procedures than are poor spellers. One of the major causative factors of this regularity is increasing uniformity of fixation length. The three good adult spellers show ranges in pause time from 4 to 18 twenty-fifths of a second, from 3 to 23 twenty-fifths of a second and from 2 to 14 twenty-fifths of a second, respectively. On the

other hand, the four fourth grade poor spellers vary their pauses from 3 to 45 twenty-fifths of a second, from 4 to 41 twenty-fifths of a second, from 2 to 40 twenty-fifths of a second, and again from 3 to 55 twenty-fifths of a second, respectively.



Subject 2, Good Third Grade Speller

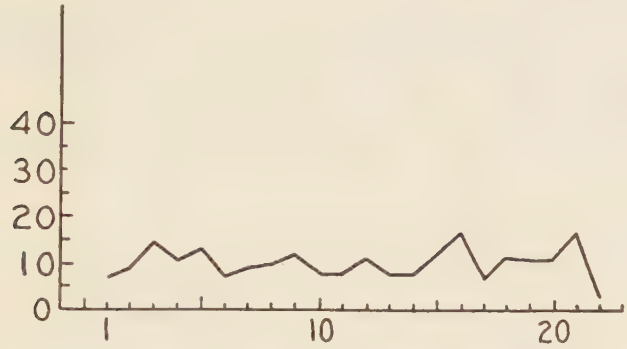


Subject 5, Poor Third Grade Speller

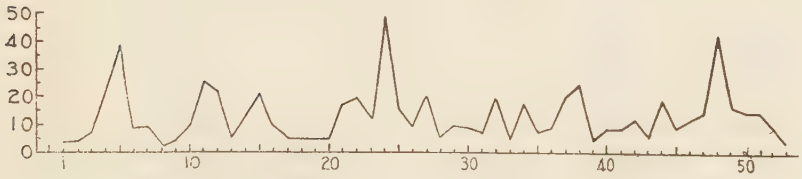
FIGURE 16. STUDY RECORDS OF SUBJECTS 2 AND 5. WORD *Biscuit*. (The numbers on the vertical axis indicate the duration of fixations in twenty-fifths of a second. The numbers on the horizontal axis indicate the serial order of the fixations.)

Figures 16–18 are presented to illustrate something of the manner in which individuals of the different levels of maturity vary with respect to uniformity of pauses. Figure 16 includes the study records for the word *biscuit* of a good third grade speller and a poor third grade speller. The fixations are charted in serial order from left to right, and the durations are indicated by the vertical axis. The good speller, Subject 2, ranged from 6 to 24 twenty-fifths of a second. The poor speller, Subject 5,

ranged from 3 to 44 twenty-fifths of a second. The difference between the two at the lower extreme is only 3 twenty-fifths of a second. Three times the poor speller reaches or drops below the shortest pause of the good speller; five times he exceeds the longest pause of the good speller by an appreciable amount.



Subject 9, Good Fourth Grade Speller



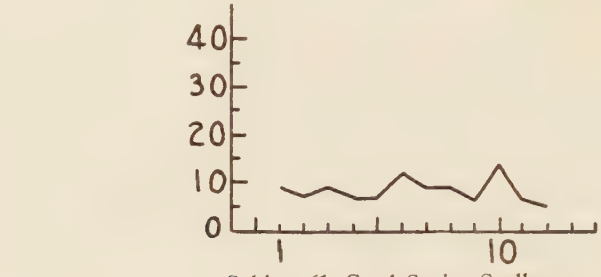
Subject 16, Poor Fourth Grade Speller

FIGURE 17. STUDY RECORDS OF SUBJECTS 9 AND 16. WORD, *Definitely*. (The numbers on the vertical axis indicate the duration of fixations in twenty-fifths of a second. The numbers on the horizontal axis indicate the serial order of fixations.)

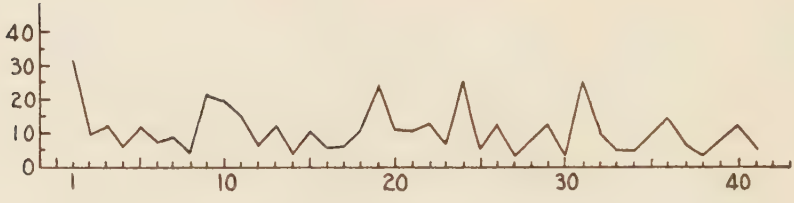
Figure 17 presents the records for the word *definitely* of two fourth grade pupils. Subject 9, a good speller, ends the study with a brief pause of 3 twenty-fifths of a second; the longest pause lasts 18 twenty-fifths of a second. Subject 16, the poor speller, only once equals the short pause, but exceeds the longest pause twelve times. Nineteen of the 22 fixations of the good speller are longer than 5 twenty-fifths of a second and shorter than 15 twenty-fifths of a second. But only 21 of the poor speller's 53 fixations fall within this range. The variations are predominantly above rather than below this range, so that if the curve of Subject

9 were superposed on the curve of Subject 16 it would lie in a low position rather than high or in the middle.

Figure 18 shows the records of two senior students for the word *ecchymosis*. The variation in length of pause of Subject 61, the good speller, is the least which has been shown in these illustrations, being from 5 to 13 twenty-fifths of a second. Less than three quarters of all the fixations of the poor speller fall within these limits.



Subject 61, Good Senior Speller



Subject 64, Poor Senior Speller

FIGURE 18. STUDY RECORDS OF SUBJECTS 61 AND 64. WORD, *Ecchymosis*

These illustrations indicate in a general way how good spellers tend to limit their pauses to narrower ranges than do poor spellers, and how good spellers limit their own ranges as they become more and more mature. Variations and exceptions frequently occur. Furthermore, perfect uniformity of pauses is not attained even by the good spellers of the adult level. The significant phenomenon here is the tendency of the good spellers to keep their fixation durations centred closely about a constant line in a low position above the horizontal axis. There is no significant difference between good and poor spellers or between mature and immature spellers with regard to the very short fixa-

tions. In the section, *Duration of Fixations,* there was brought out the decrease in the average length of fixations with the transition to maturity. It now becomes evident that the fixations are not uniformly long with immature spellers, decreasing gradually with growth; rather, fixations are extremely irregular with immaturity, alternating long and short in more or less haphazard fashion; with maturity the very long pauses are eliminated.

Table XVII shows the fixation lengths of all sixty-seven subjects. The table shows considerably more scatter for the immature spellers than for the mature spellers.

TABLE XVII

Frequency Table for Fixation Lengths

(Time expressed in twenty-fifths of a second.)

Fixation Duration	Elementary School		High School		Adults
	Poor	Good	Poor	Good	Good
2	22	3	10	8	1
3	46	19	41	22	7
4	165	56	148	84	6
5	243	94	247	162	23
6	324	98	361	210	11
7	323	109	373	178	12
8	273	136	360	150	5
9	300	125	316	114	8
10	254	89	256	94	7
11	209	70	223	73	3
12	210	70	165	55	1
13	178	51	130	49	1
14	137	37	143	36	3
15	119	36	94	22	1
16	102	24	65	24	3
17	72	29	66	20	
18	70	19	55	17	1
19	58	18	38	7	
20	54	16	30	10	
21	33	12	12	9	1
22	43	10	26	6	
23	28	4	17	3	1
24	19	10	13	3	
25–29	79	18	48	5	
30–34	47	4	15		
35–39	15	1	3		
40–44	13				
45–49	3		1		
50–54	1	1	1		
55–	2				
Total	3,442	1,158	3,257	1,361	95
Median	11.21	10.3	9.99	8.66	7.57
S.D.	6.52	5.4	5.03	4.08	3.97

Growth is perhaps more clearly evident in Table XVIII. This table shows the percentages of fixations equalling or exceeding fifteen twenty-fifths of a second for both good and poor groups

TABLE XVIII

Percentages of Fixations Fifteen or More Twenty-fifths of a Second Long—All Subjects

Fixation Length	Elementary School		High School		College
	Poor	Good	Poor	Good	Good
15 or more	22.	17.4	14.9	9.3	7.4
16 " "	18.6	14.3	12.	7.6	6.3
17 " "	15.6	12.3	10.	5.9	3.
18 " "	13.5	9.8	8.	4.4	3.
19 " "	11.5	8.1	6.3	3.2	2.
20 " "	9.8	6.6	5.1	2.6	2.
21 " "	8.2	5.2	4.2	1.9	2.
22 " "	7.3	4.1	3.8	1.2	1.
23 " "	6.	3.3	3.	.8	1.
24 " "	5.2	2.9	2.5	.6	
25–29 " "	4.6	2.1	2.1	.4	
30–34 " "	2.4	.5	.6		

of the elementary and high schools and for the good adult spellers. The table should read as follows: 7.4 per cent of the fixations of the good spellers of college level lasted 15 or more twenty-fifths of a second. And so on. The longest fixation of the adults lasted 23 twenty-fifths of a second; beyond that, 6 per cent of the fixations of the good spellers of the high school lasted 24 or more twenty-fifths of a second, and 4 per cent of their fixations lasted 25 or more twenty-fifths of a second. And so on. One or two minor irregularities appear in the table, but in general it is true that for each of the long durations, the college students employed the smallest percentage, the good high school spellers employed the next smallest percentage, then the good elementary school spellers and finally the poor elementary school spellers.

Without direct reference to individual records it is obvious that the very long pause is apt to indicate particular attention to the letter or section fixated. Here and there a protracted fixation may represent a rest period for the eye; most of the records are too short, however, to signify the need of rest.

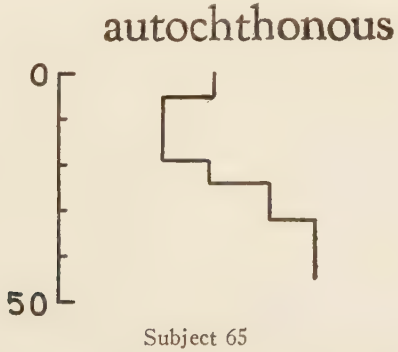
The tendency to eliminate the long pause with increasing maturity is one manifestation of a tendency to break away from detailed study of the entire word by parts. Special attention to

sections may be accomplished through other means than long fixations; these alternatives will be discussed subsequently. Careful inspection of the photographic records and analysis of the data presented prove conclusively that the long stops for special scrutiny are more protracted and more frequent in the records of the less mature subjects. The more mature the spelling habits of an individual, the less need is there for a detailed examination of all the elements of a word, and the greater is the tendency to fuse familiar elements.

The Unit of Study

A careful study of all the records indicates that the perceptual reach of the good speller is broader than that of the poor speller. The good speller of the upper levels typically limits his fixations to the middle of the word, omitting pauses from two, three or even more letters at the extremes; on the other hand, the poor speller finds it necessary to carry his fixations to the very ends of the word. Typically, also, the movements between fixations are broader for the good speller than for the poor speller of the same level, except in the case of the poor speller who, though taking long jumps, is forced to regress either to pick up something that was missed or to inspect a section in greater detail.

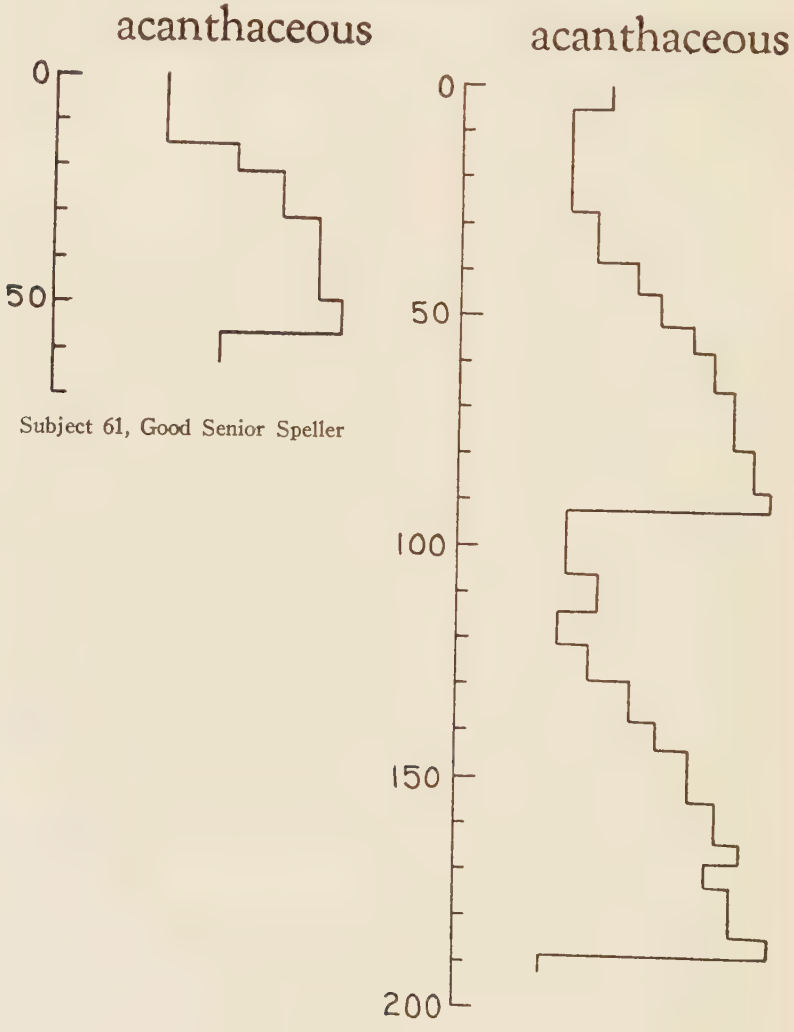
Certain illustrative examples are shown in Figures 19 to 22. The good adult speller (Fig. 19) does not fixate on the first two or last three letters of the word *autochthonous*. He moves from the first *t* to the *n*—a matter of eight letters—in four fixations.



Subject 65

FIGURE 19. STUDY RECORD OF A GOOD ADULT SPELLER

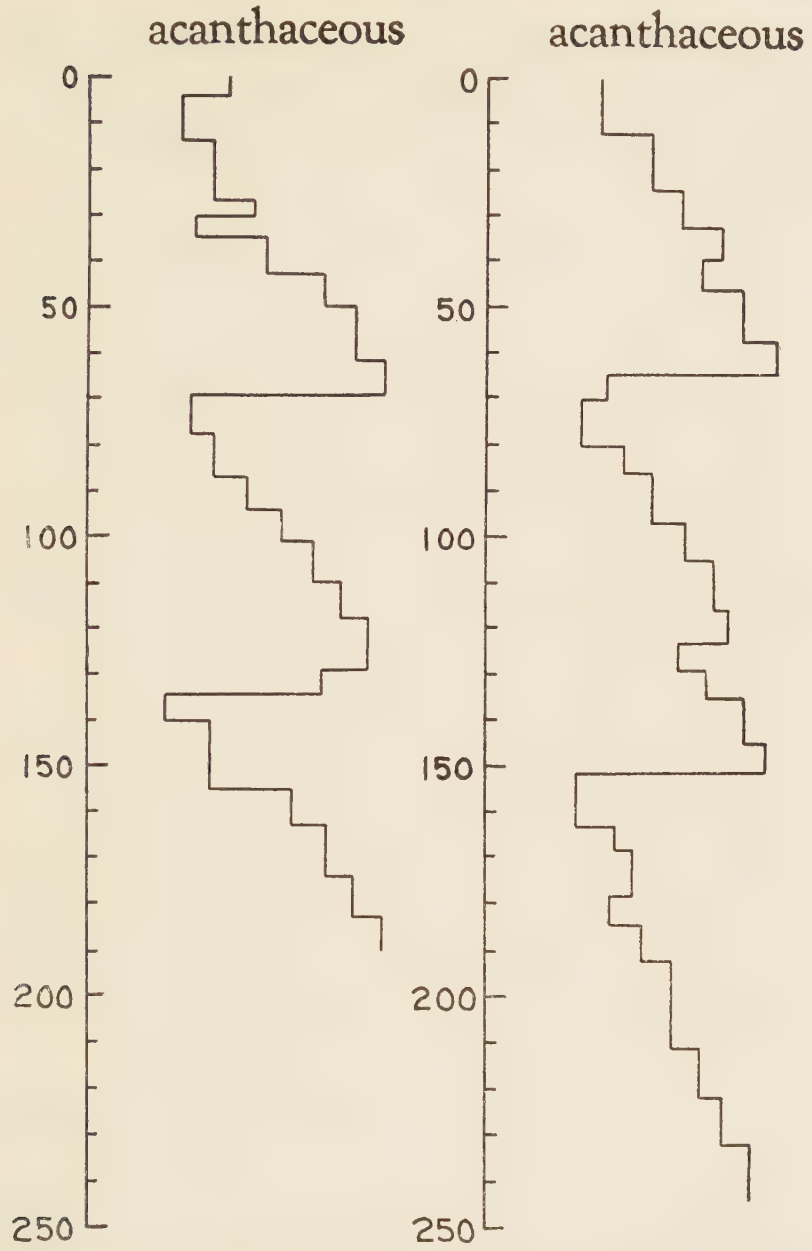
The good senior speller (Fig. 20) moves across *acanthaceous* in five fixations. He never fixates the initial *ac* or the final *s*. For the same word the poor speller requires nine and ten fixations for two cross passages, fixates both first and last letters, employs a study regression on the second passage.



Subject 61, Good Senior Speller

Subject 62, Poor Senior Speller

FIGURE 20. STUDY RECORDS OF TWO SENIOR SUBJECTS. WORD, *Acanthaceous*



Subject 47, Good Sophomore Speller Subject 51, Poor Sophomore Speller

FIGURE 21. STUDY RECORDS OF TWO SOPHOMORE SUBJECTS

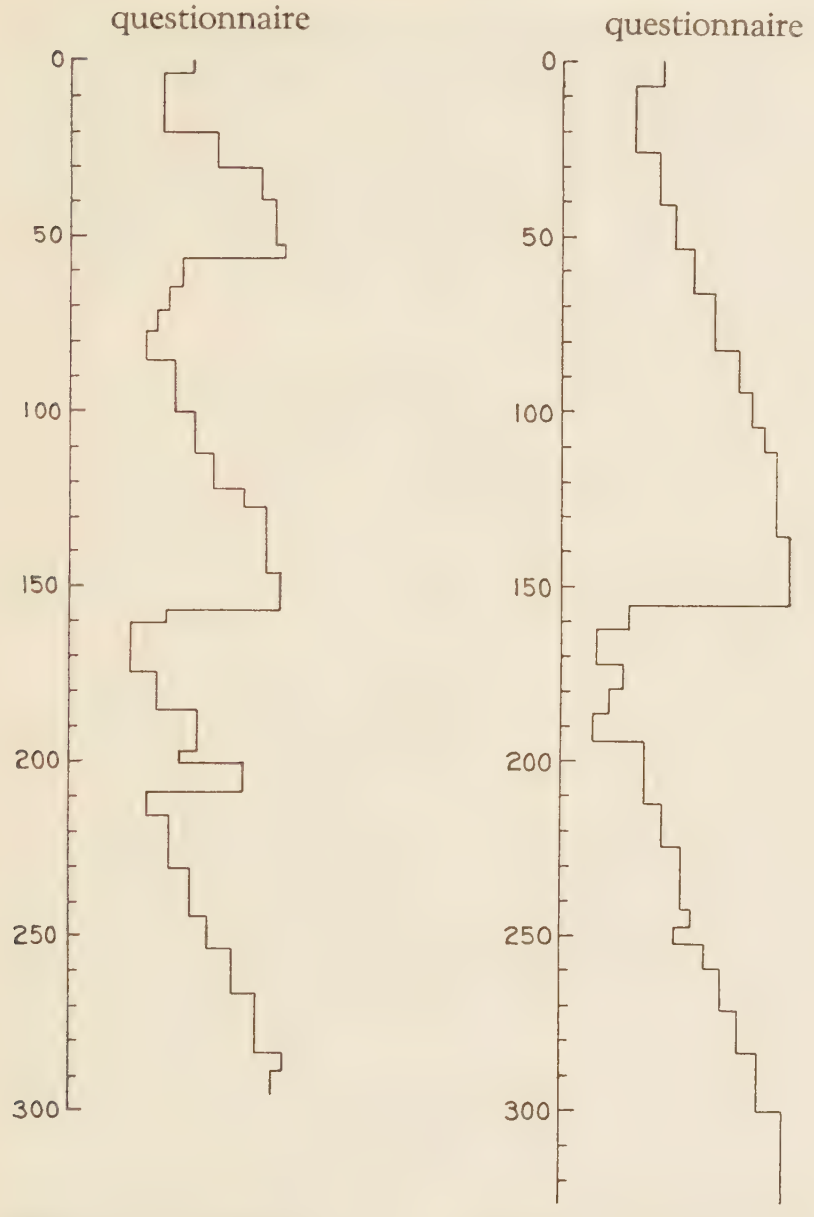
Figure 21 shows the records of two sophomores for the same word. The good speller requires eight, seven and six fixations, respectively, to go across the word, regresses but once during the cross studies. The poor speller requires seven, ten and nine fixations respectively, regresses three times during the cross studies.

Figure 22 presents the records of two fourth grade subjects for the word *questionnaire.* The good speller omits fixations from the first and last letters, makes three forward cross passages, requires five, seven and thirteen pauses respectively to study across. The poor speller goes to the very ends of the word, makes two trips, employs ten and eleven fixations respectively.

In measuring the unit of study it is necessary to take into consideration both the tendencies which have been brought out in these illustrations. It is not feasible merely to measure the distances traversed between pauses. Such a technique would neglect the good speller's long reach at the ends of the words and the poor speller's relatively frequent resort to regressions.

The technique adopted in this investigation takes into account both these phenomena. It consists of singling out all the full cross passages in the record and determining the number of letters traversed in the aggregate and dividing by the number of fixations required in making the passages. Subject 61 (Fig. 20) makes one cross passage over *acanthaceous* with five pauses; the study unit for this word is 2.4 letters. Subject 65 (Fig. 19) made one complete cross passage over *autochthonous;* 13 letters to 4 fixations indicates a grasp of 3.25 letters. Subject 14 (Fig. 22) required 21 fixations to study twice over *questionnaire;* 26 divided by 21 suggests a grasp of 1.3 letters.

To be sure, this technique does not take into account all the fixations which are accessory to the fundamental cross study patterns. For example, it does not take into account the first fixation in the study of *autochthonous* in Figure 19. But it is impossible to say what letters were grasped during this pause; it could only be included by assigning to it an arbitrary number of letters. As has been brought out, the left-to-right study



Subject 12, Good Fourth Grade Speller

Subject 14, Poor Fourth Grade Speller

FIGURE 22. STUDY RECORDS OF TWO FOURTH GRADE SUBJECTS

progress is a fundamental feature of learning to spell. The determination of the grasp exhibited in the total number of these cross passages for each student must be regarded as more than a fair sampling.

The study units for all subjects have been computed according to this technique. The averages for the third grade are presented in Table XIX. The average unit for the good spellers is approximately a quarter of a letter broader than that for the poor spellers.

TABLE XIX

The Average Study Unit (Expressed in Letters)—Third Grade

Subjects	Third Grade
Good Spellers	1.43
Poor Spellers	1.15
Good and Poor	1.29

Table XX presents the data for the fourth, fifth and sixth grades. At each level the superiority of the good spellers is marked.

TABLE XX

The Average Study Unit (Expressed in Letters)—Fourth, Fifth and Sixth Grades

	Grade		
Subjects	Fourth	Fifth	Sixth
Good Spellers	1.32	1.85	2.04
Poor Spellers	.99	1.00	1.20
Good and Poor	1.16	1.43	1.62

The averages for the high school and college subjects are shown in Table XXI. As in the elementary school, the study unit of the good speller is broader than that of the poor speller at every level.

TABLE XXI

The Average Study Unit (Expressed in Letters)—High School and College Groups

	Grade					
Subjects	Subfr.	Fresh.	Soph.	Junior	Senior	College
Good Spellers	1.65	1.63	1.92	1.84	2.23	3.13
Poor Spellers	1.08	1.27	1.35	1.33	1.46	
Good and Poor	1.37	1.45	1.64	1.59	1.85	

Figure 23 expresses graphically the data of Table XX. Growth for the good spellers through the upper elementary grades is regular and rapid. It is fairly regular also for the poor spellers, but is much less rapid.

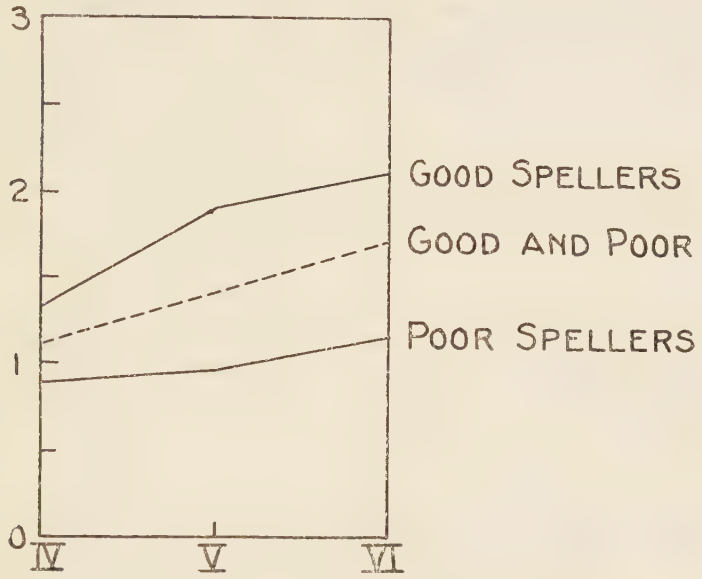


FIGURE 23. AVERAGE STUDY UNITS—FOURTH, FIFTH AND SIXTH GRADES
(Expressed in letters)

Figure 24 presents graphically the data of Table XXIV. Growth for the good spellers continues through the high school and college years, with but minor insignificant irregularities. With the poor spellers of the high school there is growth also—slight but consistent and with no irregularity of sufficient importance to merit special attention.

The data point clearly to the fact that as individuals become more and more mature with respect to words of a given level their study units become increasingly broad. Fourth grade good spellers employ an average unit somewhat broader than one letter; sixth grade good spellers employ an average unit somewhat broader than two letters. For the more difficult words of Set Three good subfreshmen average a grasp of a letter and a half

while good adult spellers average a grasp of about three letters. And so on. A college student whose study period was merely a verification of her original correct spelling (Subject 66, *autochthonous*) grasped between four and seven letters per fixation. Maturity of eye movement behavior in spelling approaches very close to this simple verification process.

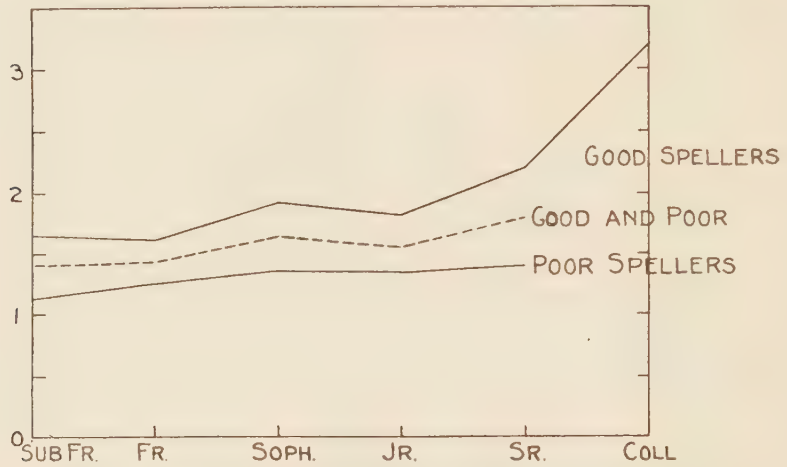


FIGURE 24. AVERAGE STUDY UNITS—HIGH SCHOOL AND COLLEGE SUBJECTS (Expressed in letters)

Perhaps the most striking fact brought out by Figures 23 and 24 is the contrast between the slight increase in span on the part of the poor spellers and the rapid increase on the part of the good spellers. In other words, poor spellers remain at a low level of apprehension no matter what words they study, whereas good spellers rapidly develop a mature method in respect to words of a given level.

Previous sections have shown that good learners do not make as many or as long fixations as poor learners. The good speller expends less eye movement energy, but works more effectively. In part at least, the secret of effectiveness lies in the breadth of the recognition span. The good speller of the sixth grade takes in almost twice as much at a glance as the poor speller of the fourth grade. The good speller of the adult level corrects errors made two or more letters distant from his nearest fixation.

Obviously, good teaching in spelling should attempt to develop a high level of apprehension. Spelling requires exact knowledge; exact knowledge connotes certainty with respect to every letter; certainty connotes effectual attention to every letter. But attention to every letter does not necessitate individual fixations. Detailed analysis appears to be a first and necessary step; of necessity, remedial measures must at times narrow down visual concentration to minute parts of the word. Such measures, however, should be undertaken with a view to extending the grasp eventually. In general it is true that the more mature the spelling habits of the individual, the broader is his unit of study.

Regressions

In determining the significant facts with regard to regressions in the study of spelling, the first step consisted of finding the average number of regressions per letter for the good and poor spellers of all levels. The data for the third grade are presented in Table XXII.

TABLE XXII

Average Number of Regressions Per Letter—Third Grade

Subjects	Third Grade
Good Spellers	.6
Poor Spellers	1.
Good and Poor	.8

The number of regressions at this level is almost almost twice as great for the poor spellers as for the good.

Table XXIII presents the averages for the good and poor spellers of the fourth, fifth and sixth grades. For each of these years the superiority of the good spellers is marked.

TABLE XXIII

Average Number of Regressions Per Letter—Fourth, Fifth and Sixth Grades

	Grade		
Subjects	Fourth	Fifth	Sixth
Good Spellers	.9	.5	.5
Poor Spellers	1.2	1.6	1.2
Good and Poor	1.1	1.1	.9

The data for the high school and college subjects are presented in Table XXIV. As in the elementary school, the good spellers regularly use fewer regressions than do the poor spellers.

TABLE XXIV

Average Number of Regressions Per Letter—High School and College Groups

Subjects	Grade					
	Subfr.	Fresh.	Soph.	Junior	Senior	College
Good Spellers	.5	.5	.5	.4	.4	.2
Poor Spellers	1.5	1.5	.7	1.	.6	
Good and Poor	1.	1.	.6	.7	.5	

Figure 25 presents graphically the data of Table XXIII. For the good spellers the curve slopes downward from the fourth

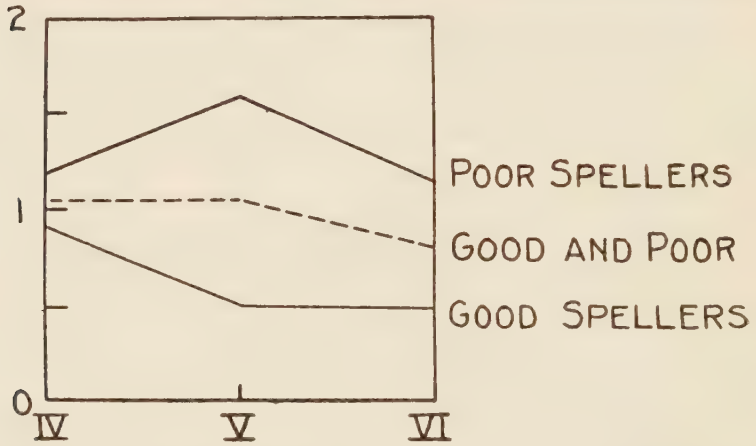


FIGURE 25. AVERAGE NUMBER OF REGRESSIONS PER LETTER—FOURTH, FIFTH AND SIXTH GRADES. (The number of regressions is indicated by the vertical axis.)

grade to the fifth. The position of the fifth grade is maintained by the sixth. The curve for the poor spellers is irregular, due to a low position of the fourth grade group, probably explained by the failure of these subjects to make an appreciable gain during the study period.

Figure 26 presents graphically the data of Table XXIV. During the first three years of high school, the good spellers make no improvement; the curve drops after the sophomore year and

again after the senior year. For the poor spellers there is no appreciable improvement until after the freshman year. From there on the descent is rather steep, even in spite of a peak at the junior level, due to two minor group variations; the sophomores use rather fewer regressions than might have been expected, the juniors use rather more.

On the whole the good spellers may be said to decrease the number of their regressions with growth. The growth of the poor spellers is irregular; in the upper elementary grades there is a tendency to increase the backward movements and permanent

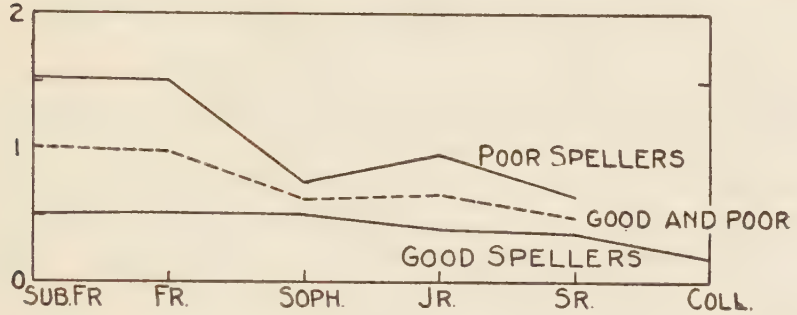


FIGURE 26. AVERAGE NUMBER OF REGRESSIONS PER LETTER—HIGH SCHOOL AND COLLEGE GROUPS. (The number of regressions is indicated by the vertical axis.)

decrease does not take place until after the freshman year—when the formal study of spelling is no longer required.

It is of interest to inquire into the types of regressions which appear in spelling. Analysis of photographic records in graphic form leads to the identification of six main types. First, there is the regressive movement which takes place at the beginning of the study after the preliminary technique of fixating a dot above the last letter of the word. This type of behavior is to be expected; it cannot be regarded as a token of immaturity. It may be called an adjustment regression. With it may properly be grouped the short backward movement at the beginning of the word where the return sweep of the eye has failed to carry the fixation far enough and an additional regressive movement is required. Both of these types are for the purpose of putting the

fixation at a place which is advantageous for beginning the cross study. Figure 27 presents illustrative drawings.

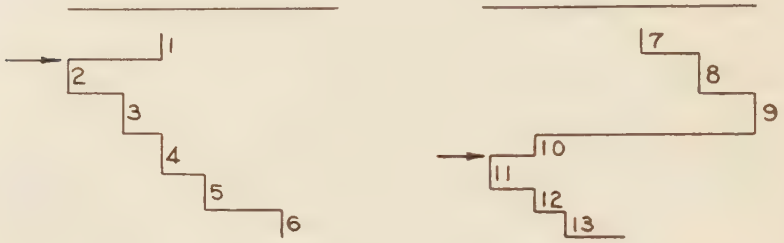


FIGURE 27. THE ADJUSTMENT REGRESSION. (The numbers beside the fixations indicate the serial order.)

Approximately 18 per cent of all the regressions were of this type. Table XXV shows the percentages by grades and by quality of spelling. The table should read: Twenty per cent of the regressions made by the good spellers of the third grade were of the adjustment type; 15 per cent of the regressions made by the good spellers of the fourth grade were of this type. And so on.

TABLE XXV

Percentages of Regressions of the Adjustment Type

(Double lines indicate groups using same sets of words.)

	Grade									
Subjects	3rd	4th	5th	6th	Subf.	Frsh.	Soph.	Jr.	Sr.	Col.
Good Spellers	.20	.15	.22	.23	.18	.17	.26	.28	.29	.33
Poor Spellers	.20	.11	.14	.16	.12	.08	.11	.15	.17	

Within the groups using the same words the table shows a grade to grade increase in percentages for both good and poor spellers. The explanation of this phenomenon is clear: the customary midway fixation practically necessitated regressive movements to begin the first study across the word. For the mature speller these regressions constituted about a third of the total number. Farther down the maturity scale the number is not less, but loses some of its importance because of the number of other regressions; the number of short backward movements following the long backward sweep is not sufficient to alter the general trend.

About one-fifth of the regressions were long backward movements from right to left of the word to begin the forward cross study again. This type of regression is to be expected from the very nature of the study progression. It occurs in the records of both good and poor spellers at all levels. There is no significant difference between good and poor spellers in the extent to which they make use of this regression, nor is there any consistent grade to grade growth.

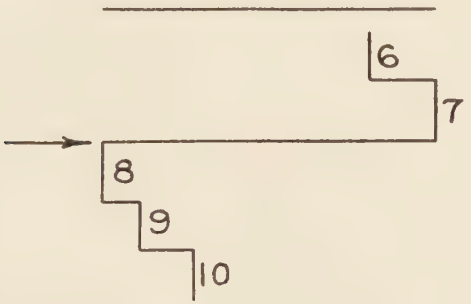


FIGURE 28. ILLUSTRATIVE DRAWING OF THE LONG, BACKWARD SWEEP TYPE OF REGRESSION

The third type of regression may be called the backward study regression; here the fixation is of such a length as to suggest the contemplation of the unit rather than merely the attaining of a new position. Apparently the phenomenon is unique with spelling; so far as the writer can ascertain it has not been reported in any other investigation of eye movement behavior. It is found at all levels in the records of both good and poor spellers: it is significant neither of maturity nor immaturity.

TABLE XXVI

Percentages of Regressions of the Long, Backward Sweep Type

(The double lines indicate groups using same sets of words.)

	Grade									
Subjects	3rd	4th	5th	6th	Subf.	Frsh.	Soph.	Jr.	Sr.	Col.
Good Spellers	.20	.23	.19	.26	.24	.30	.29	.26	.24	.21
Poor Spellers	.23	.16	.23	.26	.20	.21	.31	.17	.24	

TABLE XXVII

Percentages of Regressions of the Backward Study Type

(The double lines indicate groups using same sets of words.)

	Grade									
Subjects	3rd	4th	5th	6th	Subf.	Frsh.	Soph.	Jr.	Sr.	Col.
Good Spellers	.11	.31	.23	.22	.30	.20	.15	.14	.29	.33
Poor Spellers	.15	.30	.16	.13	.25	.20	.20	.41	.18	

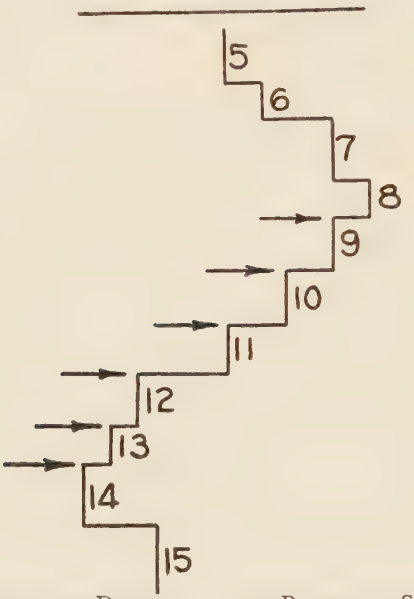


FIGURE 29. ILLUSTRATIVE DRAWING OF THE BACKWARD STUDY REGRESSION

Only about 9 per cent of all the regressions were of the fourth type, the " pick-up " regression, resulting from the effort to grasp in a single fixation too large a unit. In this case the backward movement is shorter than the preceding forward movement. This overreaching takes place more often with poor spellers than with good ones, but is not confined to immature study. It occurs at all levels.

TABLE XXVIII

Percentages of Regressions of the " Pick-Up " Type

(The double lines indicate groups using same sets of words.)

	Grade									
Subjects	3rd	4th	5th	6th	Subf.	Frsh.	Soph.	Jr.	Sr.	Col.
Good Spellers	.07	.09	.08	.08	.04	.05	.05	.12	.06	.10
Poor Spellers	.08	.10	.15	.12	.11	.10	.09	.09	.18	

Occasionally there appears in a record a fifth type of movement resulting from the oscillation of the eye. This is relatively rare. It never occurs in the study of good spellers of the more mature levels. It is to be interpreted as symptomatic of immaturity.

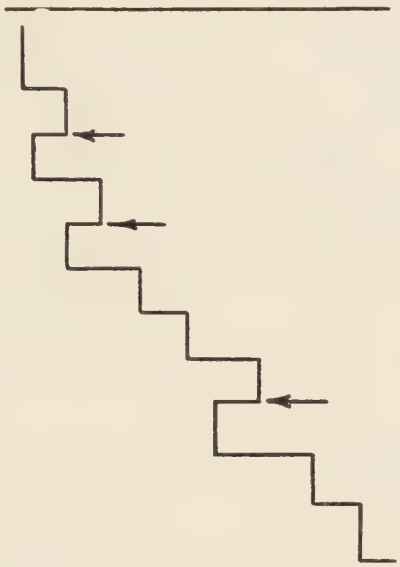


FIGURE 30. THE "PICK-UP" REGRESSION RESULTING FROM OVERREACHING

TABLE XXIX

Percentages of Regressions of the Oscillation Type

	Grade									
Subjects	3rd	4th	5th	6th	Subf.	Frsh.	Soph.	Jr.	Sr.	Col.
Good Spellers	.00	.02	.02	.01	.00	.00	.00	.00	.00	.00
Poor Spellers	.03	.01	.02	.01	.03	.01	.00	.00	.00	

The sixth type of regression results from repeated study of a fractional part of a word. Here the backward movement is as great as or greater than the preceding movement. About 26 per cent of all the regressions were of this kind. The percentage data by grades are significant. Table XXX shows that at every level except two the good spellers employ a smaller percentage of regressions indicating repeated study of the word part by part than do poor spellers. Of further interest is the grade to grade decrease for both good and poor spellers after the freshman year

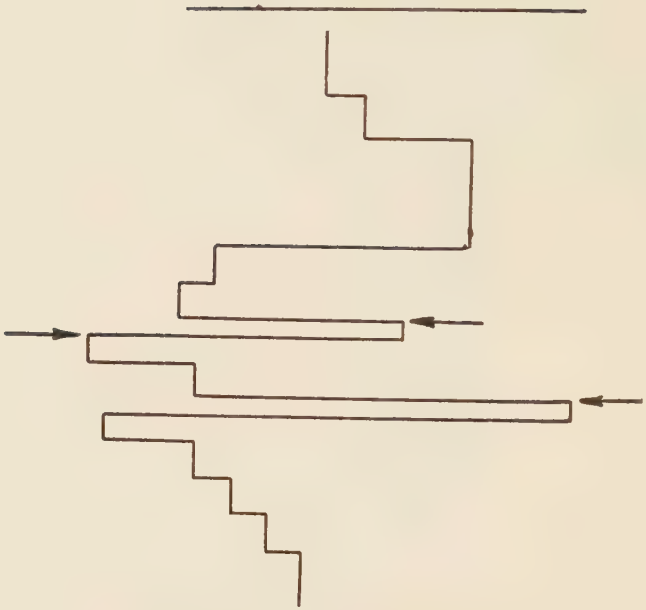


FIGURE 31. THE OSCILLATION REGRESSION

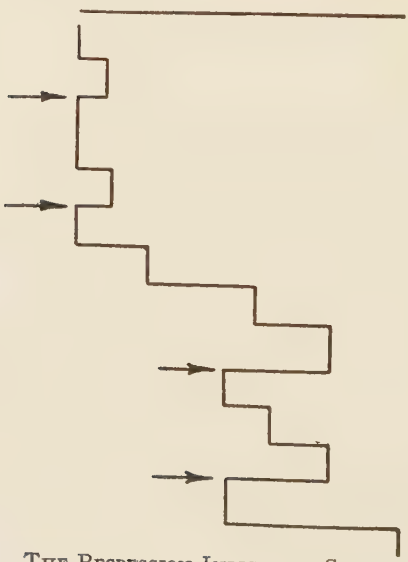


FIGURE 32. THE REGRESSION INDICATING STUDY BY PARTS

in high school. There is indication that with complete maturity with respect to words of a given level, detailed study of the word part by part is eliminated.

By way of summary, then, with the approach of maturity the total number of regressive movements tends to decrease. Poor spellers regress more often than do good spellers. Certain types of regressions appear in the records at all levels and do not necessarily represent undesirable study habits.

TABLE XXX

Percentages of Regressions Indicating Repeated Study of Parts of the Word

	Grade									
Subjects	3rd	4th	5th	6th	Subf.	Frsh.	Soph.	Jr.	Sr.	Col.
Good Spellers	.42	.20	.26	.20	.24	.28	.25	.20	.12	.03
Poor Spellers	.31	.32	.30	.32	.29	.40	.29	.18	.23	

The oscillation regression, however, occurs only in the records of those spellers who are relatively immature. It occurs so infrequently even in these records as to be of little significance, except in indicating the necessity of guiding pupils to systematic study. Teachers of beginners should guard against a random, oscillatory attack on words.

The regression indicating mere detailed study, letter by letter or part by part, likewise occurs more frequently in immaturity than in maturity. It appears to be true that in the early stages of learning to spell the careful examination of each letter or part of the word is necessary. This detailed scrutiny is accomplished in one or more of three ways—by the frequency of fixations with very short movements, by the protraction of the fixations, by certain regressive movements. As familiarity with letters and letter combinations increases, a process of fusion or synthesis operates, so that recognition takes place with less expenditure of eye movement energy.

While the regression indicating study of parts of the word appears less and less frequently with the approach to maturity, it persists to some extent at all levels. The explanation of this phenomenon and the manner of the transition to maturity will be described more fully in subsequent sections in which individual records are analyzed.

PART TWO

Methods of Attack in Efficient Study Procedures With Easy Words

What methods, as indicated by eye movements, are used in efficient study procedures with easy words? In order to answer this question five records for each of the words of Set Three were selected for special analysis. In each case the initial spelling of the word was 70 per cent or more correct, indicating that the word was relatively easy to start with; in addition, the final spelling was 100 per cent correct, indicating that the learning procedure was effective.

For the word *ecchymosis,* the five records examined were those of Subjects 61, 55, 47, 42 and 34; for *acanthaceous,* those of Subjects 61, 60, 66, 67 and 54; for *autochthonous,* those of Subjects 42, 53, 61, 65 and 67; for *pteridophyte,* those of Subjects 54, 55, 65, 66 and 67; and for *tachygrapher,* those of Subjects 34, 59, 60, 61 and 65. All of these are good spellers. Each record was analyzed with direct reference to the subject's original spelling.

For example, Figure 33 is the record of Subject 61, a good speller of the senior year of high school. His pre-spelling was *echimosus.* No fixations fall on the first two or the last two letters of the word. The majority fall on or near the positions of the first two errors. Although only one fixation falls near the third error, it is of sufficient duration to indicate some special attention to the error. The study proceeds chiefly by two surveys of the word as a whole, but with special analysis of the most difficult spot. The units of study are clearly greater than one letter, yet there is no evidence of study by syllables; in fact, on each cross passage the two syllables *mosis* are dismissed with a single fixation. All the study regressions are confined to the section of greatest difficulty; one occurs for the purpose of picking up something that was missed by too long a move preceding, three are of the backward study type. It seems clear that the

last two syllables of this word presented no difficulties; apparently the minor vowel error in the final syllable was cleared up by a fixation only slightly longer than the average. All the detailed study was confined to the preceding section where two errors occurred in the subject's original spelling and where the combination of letters was somewhat unusual.

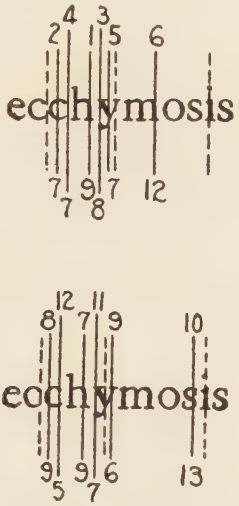


FIGURE 33. RECORD OF SUBJECT 61, GOOD SPELLER, SENIOR YEAR. (Broken lines mark the positions of original errors.)

Figure 34 is the record of Subject 55, a good speller of the junior year. His original spelling was *eccemosis*. Again there is indication of more attention to the middle of the word than to the ends, and of special concentration about the points where the original errors occurred. Except for the detailed analysis of this section the study proceeds across the word as a whole, with the recognition span at first somewhat greater than one letter, and increasing on the second passage to cover the syllable. Less than a third of the fixations are regressions: one is an adjustment regression, one is a pick-up regression, three are backward study regressions; all are centred closely about the point of difficulty.

In similar fashion but in briefer form the analyses for all

twenty-five records are presented in Table XXXI. The table shows that in all the figures there is definite indication of a tendency to confine fixations within the middle section of the word; the letters at or near the extremes of the word appear to have some advantage over the others. In five records corrections were made where the original error was two or more letters distant from the nearest fixation; the table does not show it since

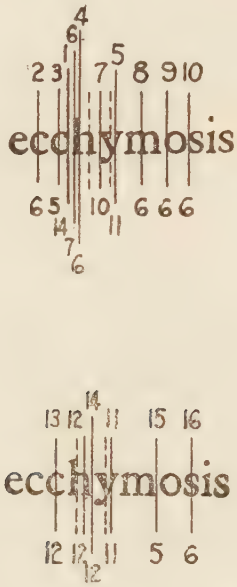


FIGURE 34. RECORD OF SUBJECT 55, GOOD SPELLER, JUNIOR YEAR. (Broken lines indicate positions of original errors.)

it does not occur consistently enough to be regarded as a tendency. The recognition span of the effective learner is broad. While some individuals tend to study by syllables, many more employ a unit larger than a letter which does not appear to conform to the syllable; its breadth varies with individuals. The majority of the records involving repetitions of the cross study over the word revealed a tendency to broaden the unit with increasing familiarity with the spelling.

In general, study proceeds in cross passage fashion over the word as a whole, rather than part by part. Where hard spots

occur there is clear evidence of a tendency to employ analysis to clear up the difficulty. This analysis may involve study regressions, protracted fixations, greater frequency of fixations.

TABLE XXXI

Tendencies in Effective Study Procedures with Easy Words—High School and College Subjects

Tendencies to: Number of Cases	ecchymosis	acanthaceous	autochthonous	pteridophyte	tachygrapher	TOTAL
	5	5	5	5	5	25
Confine fixations to middle of word	5	5	5	5	5	25
Concentrate on hard spots	4	3	5	4	4	20
Pay no special attention to hard spots	1	2	0	1	1	5
Study mainly by surveys, rather than part by part	5	5	5	5	5	25
Study mainly letter by letter within surveys	0	0	0	0	0	0
Study mainly syllable by syllable within surveys	1	1	2	0	1	5
Study mainly by non-syllable units larger than one letter	4	4	3	5	4	20
Repeat survey	4	2	2	3	4	15
Increase span with each repetition of survey	3	1	2	2	3	11
Employ study regressions	5	2	5	3	3	18
Confine study regressions mainly to hard spots	5	2	5	3	3	18
Make study regressions at other than hard spots	0	0	0	0	0	0

While study proceeds mainly by progression rather than regression, some regressive movements occur in all the records analyzed. None of them is of the oscillation or confusion type. Adjustment and long backward sweep regressions are apt to occur whenever it becomes necessary to attain a position at the left of the word to begin a cross passage over it. In addition there occur certain study regressions, that is, regressions indicating that the grasp has been overreached, regressions indicating backward study and occasionally, regressions indicating repeated study of parts. These study regressions are confined almost entirely to the difficult parts of the word. In these records the backward study regression occurs more often than the pick-up regression or the regression indicating repeated study of parts.

It has been brought out that most of these figures indicate some special analysis of the difficult parts. But the table further shows that in five of the procedures such detailed analysis is either

twenty-five records are presented in Table XXXI. The table shows that in all the figures there is definite indication of a tendency to confine fixations within the middle section of the word; the letters at or near the extremes of the word appear to have some advantage over the others. In five records corrections were made where the original error was two or more letters distant from the nearest fixation; the table does not show it since

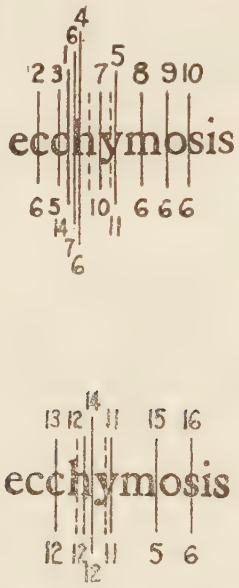


FIGURE 34. RECORD OF SUBJECT 55, GOOD SPELLER, JUNIOR YEAR. (Broken lines indicate positions of original errors.)

it does not occur consistently enough to be regarded as a tendency. The recognition span of the effective learner is broad. While some individuals tend to study by syllables, many more employ a unit larger than a letter which does not appear to conform to the syllable; its breadth varies with individuals. The majority of the records involving repetitions of the cross study over the word revealed a tendency to broaden the unit with increasing familiarity with the spelling.

In general, study proceeds in cross passage fashion over the word as a whole, rather than part by part. Where hard spots

occur there is clear evidence of a tendency to employ analysis to clear up the difficulty. This analysis may involve study regressions, protracted fixations, greater frequency of fixations.

TABLE XXXI

Tendencies in Effective Study Procedures with Easy Words—High School and College Subjects

Tendencies to:	ecchymosis	acanthaceous	autochthonous	pteridophyte	tachygrapher	TOTAL
Number of Cases	5	5	5	5	5	25
Confine fixations to middle of word	5	5	5	5	5	25
Concentrate on hard spots	4	3	5	4	4	20
Pay no special attention to hard spots	1	2	0	1	1	5
Study mainly by surveys, rather than part by part	5	5	5	5	5	25
Study mainly letter by letter within surveys	0	0	0	0	0	0
Study mainly syllable by syllable within surveys	1	1	2	0	1	5
Study mainly by non-syllable units larger than one letter	4	4	3	5	4	20
Repeat survey	4	2	2	3	4	15
Increase span with each repetition of survey	3	1	2	2	3	11
Employ study regressions	5	2	5	3	3	18
Confine study regressions mainly to hard spots	5	2	5	3	3	18
Make study regressions at other than hard spots	0	0	0	0	0	0

While study proceeds mainly by progression rather than regression, some regressive movements occur in all the records analyzed. None of them is of the oscillation or confusion type. Adjustment and long backward sweep regressions are apt to occur whenever it becomes necessary to attain a position at the left of the word to begin a cross passage over it. In addition there occur certain study regressions, that is, regressions indicating that the grasp has been overreached, regressions indicating backward study and occasionally, regressions indicating repeated study of parts. These study regressions are confined almost entirely to the difficult parts of the word. In these records the backward study regression occurs more often than the pick-up regression or the regression indicating repeated study of parts.

It has been brought out that most of these figures indicate some special analysis of the difficult parts. But the table further shows that in five of the procedures such detailed analysis is either

A similar analysis of efficient study procedures for the words of Set Two by elementary school subjects is shown in Table XXXII. All of these subjects were 70 per cent or more correct in their original spellings of the words analyzed, and all made 100 per cent gain during the learning period. For the word *definitely* only four records are presented, since only four subjects found the word easy. For each of the other words, five records are presented. For *definitely,* the records of Subjects 9, 17, 18 and 27 are analyzed; for *accommodate,* the records of Subjects 11, 17, 18, 26 and 27; for *rheumatism,* those of Subjects 18, 19, 26, 27 and 28; for *conscientious,* those of Subjects 19, 25, 26, 27 and 28; and for *questionnaire,* those of Subjects 17, 18, 19, 20 and 27.

The table shows that in the main the same tendencies obtain with these elementary school pupils as with the more advanced students. One difference of degree comes to light in the greater frequency in this group of study regressions appearing at other than the difficult sections.

TABLE XXXII

Tendencies in Effective Study Procedures with Easy Words—Fourth, Fifth and Sixth Grade Subjects

	definitely	accommodate	rheumatism	conscientious	questionnaire	TOTAL
Tendencies to: Number of Cases	4	5	5	5	5	24
Confine fixations to middle of word	4	5	4	5	4	22
Concentrate on hard spots	3	4	5	5	5	22
Pay no special attention to hard spots	1	1	0	0	0	2
Study mainly by surveys, rather than part by part	4	5	5	5	5	24
Study mainly letter by letter within surveys	0	0	0	0	1	1
Study mainly syllable by syllable within surveys	1	1	1	1	1	5
Study mainly by non-syllable units larger than one letter	3	4	4	4	3	18
Repeat survey	2	4	4	3	3	16
Increase span with each repetition of survey	1	2	4	2	1	10
Employ study regressions	4	4	4	4	4	20
Confine study regressions mainly to hard spots	3	4	4	3	1	15
Make study regressions at other than hard spots	1	0	0	1	3	4

While it is doubtful whether any of the most efficient learners in this group refrain completely from special attention to hard spots, some give evidence of an unmistakable tendency to decrease

the amount of such special attention. For example, Subject 27, one of the most efficient spellers of the sixth grade, pre-spelled *definitely* " definitly " Figure 39 suggests a rather even distribution of attention over the word. There is very little concentration on the final *e*.

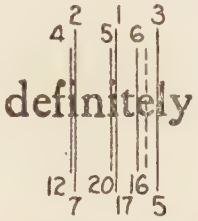


FIGURE 39. RECORD OF SUBJECT 27, GOOD SIXTH GRADE SPELLER

Subject 26 pre-spelled *accommodate* " accomodate ". Figure 39 shows a long fixation on one *m*, but the fixation is so far from the next on either side that an interpretation of routine study is just as tenable as that of special concentration.

FIGURE 40. RECORD OF SUBJECT 26, GOOD SIXTH GRADE SPELLER

Again, in studying *conscientious*, pre-spelled " consientious ", Subject 26 fixated initially on the missing *c* and even returned to

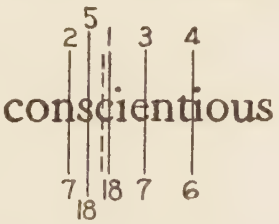


FIGURE 41. RECORD OF SUBJECT 26, GOOD SIXTH GRADE SPELLER

a point nearby for a final pause, but there is no accumulation of regressions, and the evidence of special attention to the difficult

spot is slight, particularly when comparison is made with other records showing the study of the same word.

With the words of Set One only eight subjects were photographed—four good and four poor spellers of the third grade. Of these, two found one word apiece that was easy and two found three words apiece that were easy; the learning period for all of these words was 100 per cent efficient. Three of the six records are analyzed individually.

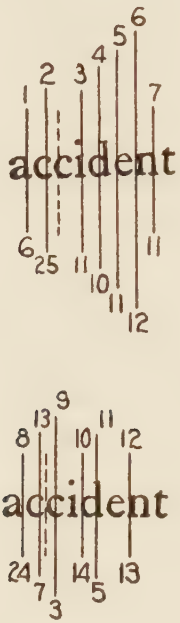


FIGURE 42. RECORD OF SUBJECT 2, GOOD THIRD GRADE SPELLER

Subject 2 pre-spelled *accident* "acident". Figure 42 shows that he studied mainly by two cross passages over the word as a whole, chiefly letter by letter. The extremely long fixation on the first *c* and the final return to it suggest special attention to it. However, the density of fixations is fairly uniform over the word.

The same subject pre-spelled *quarantine* "quarentine". He studied this word mainly by two cross passages. A comparison of the duration of fixations indicates special attention to the

point of error. Fixations are scattered rather uniformly over the word in such a manner as to suggest detailed analysis of all of it.

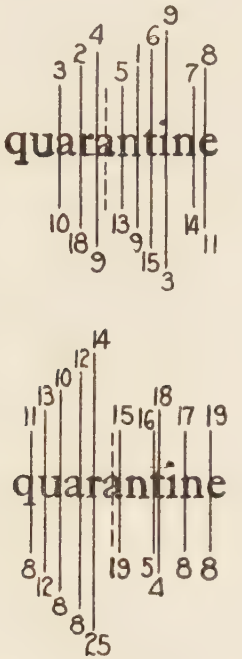


FIGURE 43. RECORD OF SUBJECT 2, GOOD THIRD GRADE SPELLER

Subject 3 pre-spelled *accident* "acsident". Figure 44 indicates one regressive cross study and two progressive cross studies. The units are larger than one letter. There is no greater indication of a special concentration on the difficult spot than on the *en*.

Although the method of attack of good spellers with easy words is substantially the same at all levels, certain differences of degree merit special mention. Young spellers who are unfamiliar with letter combinations in spelling situations tend to explore the word minutely, carefully going over all the letters. Even at this level there is evidence in selected records of particular attention to hard spots, but also there occurs detailed attention to some sections correctly spelled on the pre-test.

As experience in spelling accumulates, effective learners acquire familiarity with the manner in which letters fit together to produce certain results. As this familiarity increases a process of synthesis operates in perception so that the need for mere detailed study decreases. Typically, however, new words contain letters or letter combinations that are strange. The significant characteristic of efficient procedure is the identification of the difficulty and the employment of such means as are necessary to clear it up.

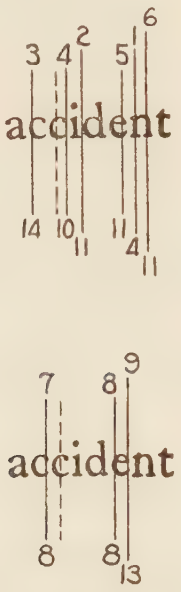


FIGURE 44. RECORD OF SUBJECT 3, GOOD THIRD GRADE SPELLER

The extent of the special attention depends upon the degree of the difficulty encountered. It ranges from fine analysis involving frequent and protracted fixations and study regressions to simple checking of the error. The most mature spellers are more or less familiar with all the combinations possible in each situation; for them noting the mistake and making the proper substitution calls forth little effort. The good speller employs nice judgment in determining what he should study and how much he should study it.

Methods of Attack in Inefficient Learning Procedures

What do eye movements indicate regarding study procedures with easy words where the learning period characteristically fails to effect appreciable gain? In order to answer this question all the records of poor spellers were singled out for examination where the initial spelling was 70 per cent or more correct and the final spelling indicated that less than half the required gain had been made; in most of these no gain at all was made.

For the words of Set Three six records were analyzed, namely, those of Subjects 64 and 52 for *acanthaceous,* of Subjects 64 and 57 for *pteridophyte* and those of Subjects 56 and 44 for *tachygrapher.* Twelve records for the words of Set Two included those of Subjects 21, 22 and 29 for *definitely,* of Subjects 13, 15, 24, 29 and 32 for *accommodate,* of Subjects 21 and 30 for *rheumatism* and of Subjects 31 and 32 for *questionnaire.* The analysis of the words of Set Three is presented in Table XXXIII, that for the words of Set Two in Table XXXIV; two third grade records are discussed individually.

TABLE XXXIII

Tendencies in Ineffective Study Procedures with Easy Words—High School Subjects

Tendencies to:	Words of Set Three 6 Cases Frequency
Confine fixations to middle of word	2
Concentrate on all hard spots	3
Pay no special attention to hard spots	1
Concentrate on some hard spots, not on others	1
Concentrate on spots other than hard ones	5
Study mainly by surveys, rather than part by part	5
Study mainly by parts	1
Employ units less than one letter	0
Employ units letter size	1
Employ non-syllable units larger than one letter	5
Repeat survey	5
Increase span with each repetition of survey	2
Confine study regressions to hard spots	2
Make study regressions at other than hard spots	4

Table XXXIII shows considerable variation in the practices of inefficient learners of the high school. Most of the records resemble those of efficient learners in indicating study chiefly by

surveys with an average grasp somewhat broader than one letter. On the other hand, more than half of the poor learners carry their fixations to the ends of the word, owing to a low level of development of the recognition span. All but one of the records point to special attention to sections other than the hard ones. Presumably the poor learners lack judgment as to what requires unusual effort; the tendency may be a carry-over from habits of minute analysis engendered in an attempt at remedial treatment. Five of the six repeat the cross passage over the word, but less than half of these increase the span upon repetition; in other words, continued attention does not result noticeably in improved apprehension.

Table XXXIV brings out similar tendencies manifested by inefficient learners of the upper grades of the elementary school. Most of the records suggest by frequent fixations at the extremes of words, letter by letter study and lack of improvement in span with cross study repetition, a low level of apprehension and slight aptitude in improving it. Lack of system and judgment reveal themselves in the appearance in the majority of records of fixations indicating special attention to some hard spots and not to other hard spots, and in the concentration on sections other than the difficult ones.

TABLE XXXIV

Tendencies in Ineffective Study Procedures with Easy Words—Fourth, Fifth and Sixth Grades

Tendencies to:	Words of Set Two 12 Cases Frequency
Confine fixations to middle of word	1
Concentrate on all hard spots	4
Pay no special attention to hard spots	2
Concentrate on some hard spots, not on others	7
Concentrate on spots other than hard ones	10
Study mainly by surveys, rather than part by part	11
Study mainly by parts	1
Employ units less than one letter	0
Employ units letter size, except at hard spots	10
Employ non-syllable units larger than one letter, except at hard spots	2
Repeat survey	10
Increase span with each repetition of survey	1
Confine study regressions to hard spots	7
Make study regressions at other than hard spots	4

Figure 45 is the record of Subject 5, a poor speller of the third grade who made no gain through study. This subject carries his fixations to the extremes of the word, studies across with an irregular span. The span on the final cross passage is narrower than on the first, second and fourth cross passages. It is extremely doubtful whether special attention is paid to the correction of the original error. Only two regressive study movements occur; one

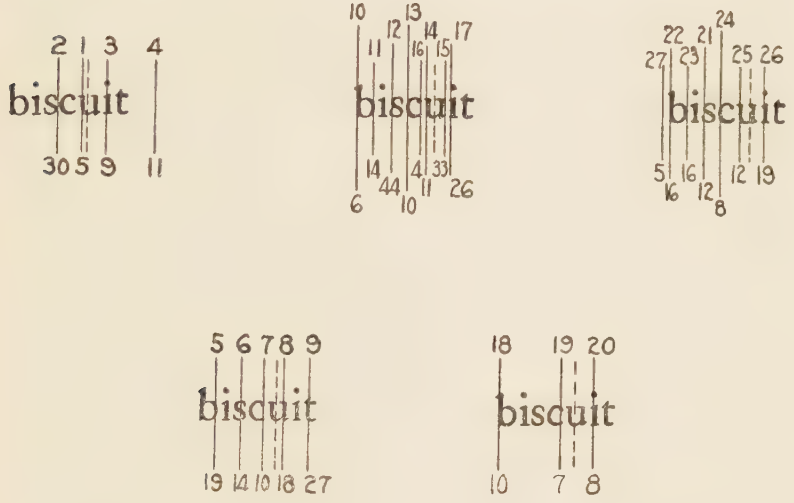


FIGURE 45. RECORD OF SUBJECT 5, POOR THIRD GRADE SPELLER

falls at the point of the original error and is extremely brief, the other falls on the initial *b* which is perhaps the easiest letter in the word. There is no unusual concentration of fixations about the *u*. While it is true that one fixation of 33 twenty-fifths of a second falls at this point, it is also true that two fixations of 30 and 44 twenty-fifths of a second, respectively, fall on the *s*. On the whole, the study is irregular, detailed, unsystematic.

Figure 46 is the record of Subject 7 for the word *scissors*, which he pre-spelled " sissers ". The study begins with a detailed inspection of the centre of the word. The *o* apparently was included in this inspection; there is no obvious reason, however, for the fine analysis of the *iss*. The *c* was given less attention than

any other letter except possibly the initial *s*. Again the minute but unsystematic analysis of the poor speller is evident.

These records are in distinct contrast to those of good spellers learning easy words. The preceding section has outlined the

FIGURE 46. RECORD OF SUBJECT 7, POOR THIRD GRADE SPELLER

manner of development of the good learner. Upon beginning the formal study of spelling he is relatively unfamiliar with letter combinations and their uses. He explores minutely, examining the word in great detail. Perhaps his eye movement be-

havior may be likened to his body behavior in play; children make countless apparently useless motions which probably result in improved control. Detailed exploration of words causes to accrue a certain familiarity with the appearance of spelling situations. Owing to the principle of fusion the recognition span enlarges and the need for continuous, detailed exploration no longer exists. The fine analysis is reserved with judicial discrimination for the clearing up of difficulties.

The poor speller likewise starts out with a detailed examination of the word. But apparently he fails to master a good method of analysis. His subsequent progress shows no parallel sloughing off of immature traits. Previous discussions have shown that even in high school the poor speller does not equal the good speller in rate of study, breadth of span, and so on; further, the development of the poor speller is irregular, inconsistent. But the outstanding deficiency of the poor speller is his failure to develop an adequate method of attack. He may lavish attention on sections of the word with which he is familiar; he may neglect hard spots. He is irregular. He fails to discriminate. He lacks effective system.

Summary of Findings

The findings of the investigation, as brought out in Part One and Part Two, may be summarized as follows:

1. The average number of fixations employed in the study of spelling is less for the good spellers than for the poor spellers in every grade. Good spellers tend to decrease their average number of fixations from grade to grade. Poor spellers exhibit an irregular tendency to increase their number somewhat during the elementary school period; after the freshman year of high school there is a sharp, though irregular decline.

2. The average study time per word is greater for the poor spellers than for the good spellers at every level. Study time for good spellers shows a more or less regular grade to grade decrease. For the poor spellers there is an irregular tendency to increase the time during the latter years of the elementary school; after the freshman year there is an irregular decrease.

3. The average time per fixation is greater for the poor spellers than for the good at every level. Both good and poor spellers exhibit a tendency to decrease the fixation time from grade to grade through the school period.

4. Fixation pause lengths are more regular for good spellers than for poor spellers, and become increasingly regular with progress through the grades. The increased uniformity is attained by the elimination of the very long pauses.

5. The study unit of the good spellers is broader than that of the poor spellers at every level. An irregular increase in breadth characterizes the grade to grade development for both good and poor spellers. For the poor spellers the increase in span is very slight, for good spellers it is very rapid with respect to words of the same difficulty.

6. At every level good spellers use fewer regressive movements than do poor spellers. The progress of the good spellers through the grades is accompanied by a slight decrease in the number of regressions. For the poor spellers growth is very irregular during the elementary period; after the freshman year of high school there is evidence of a decrease. Not all types of regressions signify immaturity; certain types decrease through the grades because fixations of all types decrease. Backward study, for example, occurs at all levels, but occurs less frequently than forward study. The data show clearly, however, that the oscillation regression and the regression indicating repeated study part by part must be regarded as characteristic of immaturity.

7. The order of progression is predominantly forward. Study is conducted typically by cross-passages over the word. The number of repetitions of the cross-passage is greater with poor spellers than with good spellers, greater with immature spellers than with mature spellers. Before the first cross-passage, between cross-passages, after the last cross-passage, there may be accessory fixations: their order and duration may suggest direct movements to attain a position advantageous for the beginning of a cross-passage, oscillation or random movements, backward study, or repeated study of parts.

8. Efficient procedure of individuals who find words easy varies with the degree of maturity. Young learners beginning spelling explore the word minutely. Increased familiarity with letter combinations results. The principle of fusion or synthesis operates so that recognition proceeds with increasing speed, regularity and width of span. But some letter combinations become familiar before others. Typically the good speller learns to differentiate between easy and hard sections. Easy sections are dismissed with little more than a mere identification reaction. Hard sections are analyzed for the purpose of clearing up the difficulties. The extent of this analysis depends upon the extent of the difficulty encountered. Good spellers of the adult level are more or less familiar with all of the letter combinations; their study is apt to include some special attention to the point of the original error, but not minute analysis.

9. In general, poor spellers fail to develop effective methods of analysis. They do not distinguish properly between hard and easy spots. Easy spots are apt to receive minute attention; hard spots may be ignored. The study is apt to be irregular, detailed, distributed without reference to the individual's needs.

Implications and conclusions

The implications for education of the findings of the investigation here reported are direct. The teaching of spelling in the early years should involve a definite method of instruction. The instruction should aim primarily to develop a systematic method of attack upon words. The teaching procedure should take into account individual differences.

The practice of assigning a word or group of words to young pupils with the command to "study for five minutes", or to "study these words until you know them" is to be condemned not merely as inefficient, but as detrimental to the formation of proper habits of study. Unless the child has mastered a proper technique, such directions will, in all probability, lead to slow, detailed, repeated study without any guarantee of improved efficiency. Merely to increase the amount of study does not constitute a

remedial measure for poor spellers. The proper approach lies through the development of a good type of analysis.

Different letter combinations are of varying degrees of difficulty. The pupil should be taught to distinguish between hard and easy combinations. The easy sections are those which he has mastered and accordingly require little attention; detailed exploration of such sections is undesirable and should be discouraged. The emphasis in study should be placed on the identification and analysis of those sections which are difficult. The amount of analysis should depend upon the extent of difficulty which the situation presents.

Letter combinations which are difficult for one individual may be easy for another. Obviously it is undesirable for the teacher to direct the special attention of the class to sections of the word which she thinks difficult or which some of the pupils find difficult. Each pupil should be trained to detect and correct his own errors.

In so far as it is compatible with the efficient mastery of words, study should proceed as quickly as possible. Detailed study *per se* possesses no virtue. The proper development in spelling lies through the initial analysis of difficulties and the subsequent synthesis of the mastered elements. As an individual attains complete maturity with respect to words of a given level of difficulty he comes to recognize the word as an organized unit. To facilitate this process, to prevent lagging or uneconomical multiplication of effort, the employment of frequent check tests during learning is essential.

Problems Raised.

The formulation and evaluation of devices for teaching based upon the principles revealed in the investigation constitute an inviting field of additional experimentation. The perfection of the details of method and the modifications necessary to care for individual differences properly fall within the scope of such a study.

Other problems are raised. Differences in the fundamental perceptual elements of study are evident to some extent even in

the records of good and poor spellers of the third grade. In view of the fact that these pupils have received an almost negligible amount of training in the study of spelling, it would appear that habits formed before the commencement of formal study in spelling must be partly responsible. The determination of the causation should eventuate in preventive measures which would reduce the problem of poor spellers in the schools.

Where improper habits of study have already been formed, the problem of correction looms important. To what extent can poor spellers in the high school be trained in the proper method of attack? Can poor spellers in the sixth grade become good spellers in the high school?

It would be of further interest to ascertain the reason for the improvement in the desirable study habits during the high school and college years, when formal instruction is no longer required. Conceivably, extensive reading experience and writing experience may be responsible. Or again, the improvements may be the inevitable sequellæ of elementary school training in spelling.

Psychological analysis indicates certain differences and certain similarities between processes involved in reading and spelling. The determination of the relationship as revealed through eye movements would contribute to our knowledge both of the learning and teaching of spelling.